THE UNIVERSITY OF ALBERTA

BREEDING DENSITY AND REPRODUCTIVE SUCCESS OF ROBINS IN RELATION TO HABITAT STRUCTURE ON LOGGED AREAS OF VANCOUVER ISLAND, BRITISH COLUMBIA

by

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ABSTRACT

Breeding density and reproductive success of the American robin (Turdus migratorius) in west coast forest on Vancouver Island, British Columbia were examined in relation to several components of habitat structure in the summers of 1971 and 1972.

Nesting success was low (21 percent) , but appeared adequate to replenish the population. Predation and desertion accounted for approximately equal amounts of nesting failure.

Individual robins tended to have consistent nesting fates (successful or unsuccessful). A limited amount of evidence indicates that in specific nest sites, robins are consistently successful or unsuccessful. Individual females tended to choose nest sites with similar characteristics.

Habitat was divided into dense (mean overstory cover approximately 40 percent) and open (mean overstory cover approximately 15 percent). More nests were located in dense than open areas and nests found in dense areas were more successful. Banded juveniles fledged from nests in dense habitat were sighted further distances from the nest at an earlier age than those from nests in open habitat.

Characteristics of the nest site were examined. Amount of concealment and density of vegetation in the immediate vicinity of nest sites were higher for successful than unsuccessful nests, but not significantly so. Nest height and type of site (trees, stumps or roots) did not affect success. Most robins placed their nests close to free water, but this was not

ABSTRACT

related to success of the nest.

A combination of concealment of a nest site and density of vegetation around the nest site was associated with nest success. Although sample sizes were small, trends indicated that a successful nest was likely to occur in a site surrounded by dense vegetation. If it was surrounded by open vegetation, there was a high probability that it was well concealed.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

In early avian ecological studies, lists of plant species were used to characterize the habitat typically used by species of birds. Habitat function (e.g., food supply) was considered in later studies. Recently, some authors have stressed the importance of habitat structure. Parnell (1969) studied warbler habitat relations and postulated that physical features of the vegetative substrate were important in determining the habitat occupied. His study raises several questions: If a species tends to select for a specific habitat structure, is this related to its breeding success ? If habitat structure is important to reproductive success of a species, then are some components more important than others?

The present study considered three hypotheses:

(1) Habitat structure plays a role in determining distribution and density of breeding birds.

(2) Habitat structure is important to breeding success.

(3) Some components of habitat structure are more important than others.

Numerous components in the structure of the habitat may contribute to nesting success. I have chosen two aspects: nest site characteristics and density of overstory cover.

The height, position, and concealment of the nest and proximity to free water may influence the prevalence of predation or desertion. Density of overstory vegetation immediately around the nest site and type of site may also be important.

Density of overstory cover may affect nesting success. Do

passerines select for either dense or open cover? They may simply have a different distribution of nests and home ranges in an open area as compared to that of a dense area, or there may be a difference in size of home range in each of the two areas, but nesting success may be the same. An inverse relationship exists between the amount of coniferous cover and the available vegetable food on the ground. These conflicting interests may be important: a dense habitat may provide greater security, but may also involve a greater expenditure of energy for maintenance and reproduction.

The American robin was considered a suitable species for investigating these problems for several reasons. Robins are widespread, abundant and conspicuous, and their nests are large and easy to locate. Since robins maintain populations in both natural areas and areas colonized by man, a comparison of nesting success in both areas can be made. For instance, Snow (1958) found a lower nesting success for the European blackbird (Turdus merula) in wooded areas than in urban areas in Britain. Robins in Massachusetts, U. S. A. had a lower nesting success in areas dissociated from human activities when compared to urban areas (Hester, 1964). My study allows a comparison of nesting success in an urban area of British Columbia with the natural area observed, as a recent study by Kemper (1971) in the Vancouver area provides comparative data.

Field work was conducted on a 184 hectare (453 acres) study area of east-central Vancouver Island between mid-April and September, 1971 and 1972.

STUDY AREA

A. General information

The study area (Comox Burn) is located 19.3 km (12 miles) northwest of Courtenay, (49° 45', 125° 10') Vancouver Island, British Columbia (See Figure 1). It consists of 184 hectares (453 acres) of Douglas-fir (Pseudotsuga menziesii) plantation. The area was first logged between 1947 and 1961 and was swept by a wildfire in the fall of 1961. The area was replanted with Douglas-fir during the period from 1962 to 1964. Omitting swamps and marshes, trees were planted approximately 2.5 m by 2.5 m which allowed about 1250 trees per ha (Johnson, J., Crown Zellerbach forester, Pers. Comm.).

The study area is situated within the southern Pacific coastal forest region (Rowe, 1959). It occurs in an intermediate zone between the coastal western hemlock (Tsuga heterophylla) and the coastal Douglas-fir biogeoclimatic regions (Krajina, 1965).

Comox Burn is permeated with logging roads of varying conditions. Most roads are covered with ground vegetation and volunteer conifers. Plantations continue past the west, south and north boundaries of the study area. Much of the area to the east is bounded by taller plantations (16 m) of Douglas-fir and volunteer conifers (western hemlock and western red cedar, Thuja plicata). Natural regeneration occurs to a limited extent over the entire area.

The elevation ranges from 244 m to 442 m above sea level. The relief consists of low undulating hills in roughly parallel orientation from east to west with elevation increasing

Figure 1. Map of Vancouver Island, British Columbia showing location of the study area.

gradually from east to west.

The study area has three major streams which normally flow throughout the summer, and numerous intermittent streams. Surface water flow is very irregular. In midsummer, when most small streams have dried, one day of heavy rain will cause most streams to flow. There are three major marshes ($>$0,5 ha) and numerous small damp areas.

B. Vegetation

Overstory vegetation consists largely of Douglas-fir and I have classified plantations into two types with respect to density: dense (59 ha) and open (125 ha). This classification was not always correlated with age of plantation, as trees have not grown equally well in all areas. Plantations probably have little effect on understory vegetation if their average height is less than one metre. When greater than one metre, trees have an increasing effect on understory density and species composition.

In addition to Douglas-fir, willows (Salix spp.) and red alder (Alnus rubra) are common along streams and around marshes. There are occasional thickets of volunteer western hemlock, western red cedar, and Douglas-fir, or mixtures of all three species, scattered throughout the area. Such thickets are usually small and dense, with little understory.

The ground cover was classified into one of three types with almost any species occurring in any type. The main difference between types is in density of the characteristic species, rather than in species composition of the type. The major

species characterizing a type are bracken fern (Pteridium aquilinum), trailing blackberry (Rubus vitifolius), salal (Gaultheria shallon) and Oregon grape (Mahonia nervosa). These species seldom occur in uniform stands.

The trailing blackberry type occurs over a large part of the study area. It ranges from situations where herbaceous plants give almost 100 percent cover to areas where the ground cover is only 10 percent. In general, this type is open, with much bare ground. Trailing blackberry is one of the first plants to colonize exposed slopes because of its ability to produce extensive stolons, and generally occurs on ridges or well drained areas. The average herbage height is 20 cm.

Bracken fern types occur in dense stands with little bare ground. This type is most common on low, poorly drained areas, in bottoms of gullies and other depressions. Practically all species found in the trailing blackberry type occur here, but more sparsely. Species diversity, at any one point, is much lower than in the trailing blackberry type. Bracken fern does not usually exceed 50 cm in most areas, but, in some moist areas it may have an average height of 120 cm. In spring, understory is very open, being composed largely of fallen dried stems from the previous year. Such mats may have some effect on species diversity. Dense bracken fern may affect plantations of Douglas-fir for approximately the first six years after planting. During the growing season, bracken fern may outcompete the trees for light because it is taller and more dense. Bracken fern types occur largely in open habitat but also occur around streams and marshes in dense habitat.

The salal - Oregon grape type occurs in small areas, usually not greater than 0.25 to 0.50 ha, as opposed to the previous types which may cover an area greater than 50 ha. It usually provides a cover less dense than bracken fern. Species diversity and herbage height are similar to those in the trailing blackberry type. Understory in dense habitat is predominantly of salal - Oregon grape type.

Pearly everlasting (Anaphalis margaritacea), hairy cat's ear (Hypochaeris radicatum), strawberry (Fragaria spp.), fireweed (Epilobium angustifolium), and small dense patches of vanilla leaf (Achlys triphylla), Oregon grape and salal can be found almost anywhere on the study area. Around marshes, sedges (Carex spp.) and skunk cabbage (Lysichitum americanum) are common. Thimbleberry (Rubus parvifolium), salmonberry R. spectabilis), sword fern (Polysthicum minutum), deer fern (Struthiopteris spicant), horsetail (Equisetum officinalis) and devil's club (Olopanax horridea) occur along stream beds. Red huckleberry (Vaccinium parvifolium) and rose (Rosa spp.) are most common along stream banks. Small dense patches of twinflower (Linneae borealis) and bunchberry (Cornus canadensis) occur occasionally along stream banks on the study area.

When an area has been logged, slash-burned, and trees are replanted, the argument may be put forth that this area can no longer be considered "natural". Zwickel (1972) considers the above practices to create areas similar to those following natural forest fires. Mueller-Dombois (1965) states that despite the disturbance of coastal Douglas-fir forests by logging and slash-burning, the original vegetational pattern

is only little modified during the resulting succession. He showed that characteristic forest plants were still present after logging and burning and that they largely maintained their original distribution. However, he referred only to areas with natural regeneration, not plantations. Planting trees accelerates the normal rate of secondary succession after a fire. Any seral stage after planting might correspond approximately to a seral stage in natural regeneration, but would require fewer years to reach that stage. If composition and structure of habitat after logging, slash-burning and planting corresponds to a similar stage, but different time period, after a natural fire, the area may be considered "natural" in terms of birds which normally frequent open habitat.

Black-tailed deer (Odocoileus hemionus columbianus) may enhance Douglas-fir trees as suitable nest sites for passerines. For the first six to eight years after establishment, the impact of deer browsing may be considerable. As the terminal leader of a tree is nipped, apical dominance of the tree is destroyed and a low tree with two trunks or a bushy base results. Such browsing affords passerines a well concealed nest site 50 to 100 cm above ground.

C. Climate

Comox Burn is situated within a rainshadow and is sheltered on the west by a mountain range extending the length of Vancouver Island. Generally, this region has characteristics of a maritime climate. McMinn (1965) states that although high annual precipitation is characteristic of the Pacific

northwest, rainfall is unevenly distributed, with summer months receiving a small proportion of total precipitation. The island mountains lie more or less at right angles to incoming air masses which bring much of the precipitation.

Mean monthly precipitation on the study area for May to August inclusive was 5.9 cm in 1971 and 5.4 cm in 1972. Precipitation was heavy during the first part of the 1971 nesting season and extremely light later in the season. In 1972, rainfall was interspersed throughout the nesting season.

By mid-April, most snow had melted in both years, except in a few north-facing depressions. There were several hailstorms and wet snow falls in mid-April, 1972. These usually lasted no more than a day. Most snow and hail occurred before robins arrived on the area in any numbers.

D. Length of nesting season

In 1971, the first nest was found on May 3 and incubation was first initiated on May 5. The last nesting attempt was terminated on July 17. Field work was conducted between April 17 and August 24. In 1972, robins first moved to the study area on April 14. On April 22, I first observed a female robin building a nest and the earliest date for initiation of incubation was May 4. All nests were terminated by July 27. Field work in 1972 was conducted between April 12 and August 24.

METHODS

A. Field study methods

Field work entailed four goals: location of all possible nests, capturing and marking robins, recording sightings and locations of marked individuals and an analysis of habitat.

1. Location of nests

As many nests as possible were found. Both old (built in previous years) and active nests were recorded. Some were located by observing behaviour of the adults. However, the majority of nests were located by a systematic search. If a breeding pair was located, an intensive search of the immediate area was made until the nest was found. The amount of time spent searching an area varied with numbers of breeding pairs and ease of finding nests in a specific area.

Once a nest was found, the time, date, condition of nest, general information about the nest site, vegetation and proximity to water were noted. Nests were rechecked every two to three days, usually from a distance. The female was not flushed from the nest except on dates of suspected initiation of incubation or hatching of young. The nest was subsequently approached from different directions and only five to ten seconds was spent at the nest site. This procedure was followed until fledging.

2. Capturing and marking

I individually color-marked adults and nestlings. The decision to individually mark a population involves a compromise between additional information obtained and the effect of the added disturbance. I decided to mark individuals for the

following reasons:

(1) to obtain information on nesting success of individual pairs.

(2) to more accurately estimate numbers of pairs on the area.

(3) to determine the size of area utilized by adults and fledged young.

(4) to obtain information on annual mortality, or rate of return, of adults and juveniles.

Adults were mistnetted at the nest site when nestlings were approximately four days old. This proved to be the best time to capture adults as it was necessary to mist-net when attraction to the nest site was high. This occurred after hatching, when the young were old enough to survive several hours without brooding.

Although banded pairs give a more accurate picture of the actual number of breeding birds and the number of nonbreeding individuals, I usually caught only one adult per pair because:

(1) Sometimes it was possible to catch only one, as the mate became, or was, too wary.

(2) The time required to catch one adult was much less than to catch two. Hence, capturing only one reduced disturbance and allowed more time for nest search.

(3) After catching one adult, the mate would normally return 10 to 15 minutes after I left, whereas the newly banded adult might take several hours to return. This amount of time might be critical to young nestlings.

(4) Robins do not appear to switch mates during the breeding season unless one dies. Thus complete nesting information can be obtained without banding both individuals of the pair.

(5) Although limited banding of males has proved quite interesting, banding of females was more useful because one can identify the pair to whom the nest belongs when one first finds the nest. Whenever possible, I tried to catch the female of the pair.

All adults were captured by placing a mist net two to four metres from the nest site, usually in the feeding trip flight-line of adults. Occasionally a female brooding or a male at the nest site was flushed into the net. Mist nets were usually set around 0900 hours, after morning feeding of the nestlings, but only when the weather was warm, with low winds and no rain. In 1971 and 1972, I used a portable blind which enabled me to observe activity of the adults, efficiency of the mist net and adults being caught. This reduced the amount of time adults spent in the net. If I remained visible near the nest, the adults always neglected their parental duties and scolded me.

In 1972, I made four exceptions to the above procedures. In four areas where all nests had been unsuccessful in 1971, and the same trends appeared in 1972, I selected four nests which were first nesting attempts and flushed the female off the nest into the net during early incubation. Having such banded individuals in these areas helped sort out numbers of pairs and provided additional information on consistency of nesting success of individuals.

I used colored plastic leg bands for marking, with each bird having a distinctive combination. Nestlings were banded at eight days of age, when their legs were adult-sized and there was little likelihood of premature fledging.

3. Resighting marked robins

Whenever individually color banded adults and juveniles were sighted, their activity, specific location and general information about weather and habitat were noted. Locations were recorded in reference to a master grid map.

4. Analysis of habitat structure

An analysis of habitat structure covered two aspects: density of coniferous cover and characteristics of nest sites.

The study area was type mapped after the growing season (August) to divide the habitat into dense and open areas according to average height of conifers and density of trees. Survival of plantations was rated on a scale of one to three. If all or most of the trees planted had survived, the area was rated "three". If the surviving trees were rather sparse, a rating of "one" was assigned. "Two" was used as an intermediate classification.

I had two degrees of density of coniferous cover: open and dense. Plantations with an average tree height of less than two metres, or between two and two and a half metres with a survival rating of one or two, were considered open. The remaining areas were classified as dense. Thirty plots (100 sq. m) in 1971 and 40 in 1972 were picked in a stratified random manner to examine the relationship between average tree height and coniferous cover on the area. In 1972, 22 plots were located in open areas and 18 in dense. In 1971, there were only 8 plots in dense areas. Tree crown diameter at the widest and narrowest expanse of branches was measured. Overstory cover of each tree was determined by averaging the two measurements and determining the area of a circle. Total plot cover (cover provided by all trees) was expressed as a percentage of total plot area (100 sq. m). Ground cover of the most abundant species was estimated subjectively.

Height and cover of all deciduous shrubs were also measured.

Specific nest site characteristics were recorded at the time nests were first found, to examine what parameters might be important to the fate of the nest. Each nest was given a concealment rating. A nest was considered to have six faces (four real sides, plus top and bottom). The number of faces that were concealed from a distance of one to two metres was counted and a concealment rating assigned from one to six. This procedure assumed that concealment of each face was equally important. Since most nests were built close to the ground, an exposed top probably would not make the nest any more vulnerable to avian predation than an exposed bottom or side to mammalian predation.

Vegetation that occurred within 10 m of each nest was recorded and a "type" was ascribed (based on most abundant tree and understory herb). Distance to nearest free water (marsh or stream) was recorded. Density of coniferous cover within a three metre radius of the nest site was recorded as dense or open according to criteria mentioned above for describing general habitat density. When referring to density of vegetation around the nest site, the words dense and open will not be underlined.

Other nest site characteristics were recorded in late August, after the nesting season. All nests found during the summer were revisited to mark the nest site, to note general topography of the nest site, height of nest tree and height of the nest in the tree.

B. Nest-search plots

A possible bias in this study concerned the ease with which one finds nests in habitats with differing densities of coniferous cover. In open areas, one can search all possible trees and most of the likely stumps over a large area. If a nest is extremely well hidden, an open area still has the advantage of rendering the adults more conspicuous while performing their parental duties. In dense areas, nests tend to be more exclusively in trees, but almost every tree has a potential to support a nest. Dense habitat also offers greater concealment to adults.

To test for this possible bias in my ability to find nests in dense and open areas, I set out, in 1972, 40 0.25 ha (50 m x 50 m) plots picked randomly from a grid map. This represented 5.5 percent of the total study area. Within these plots every tree, stump and log was carefully searched. Twenty two plots were in dense and 18 plots were in open areas. This search was conducted in mid-April, before the 1972 breeding season and was designed to test for a possible bias in my searching for nests in 1971.

RESULTS

A. Demographic parameters

1. Density and distribution of breeding pairs

Estimates of density and distribution of breeding pairs were derived from nest data and observations of banded individuals. Because of insufficient data, sizes of individual territories or areas of utilization could not be determined. Data were less accurate in 1971 than in 1972, because of my lack of familiarity with the species and the area.

Thirty-one pairs of robins nested on the study area in 1971 and 36 in 1972. Average density for both years was one pair every 5.5 ha. The above figures represent an average number occupying the area and compensate for pairs which might have been removed from the breeding population by a death of one or both of the pair which was not replaced. In two cases, a new pair appeared and nested on the area late in the season. In both years, density of pairs was highest in areas with dense habitat. In 1971, an average of 0.20 pairs per ha nested in dense habitat and 0.15 in open habitat. In 1972, densities were 0.27 and 0.16, respectively (Table 1). Thus density of breeding birds in dense habitat increased while it remained similar in open areas for both years. On the whole, the population was stable, or slightly increasing from 1971 to 1972.

To compare distributions of breeding pairs, centres of activity were assigned to each pair according to the relative amounts of time spent in an area. Pairs were not evenly distributed throughout the study area. Figure 2 shows a rather

YEAR	TOTAL NUMBER OF BREEDING PAIRS	DENSE HABITAT (pairs/ha)	OPEN HABITAT (pairs/ha)
1971	31	0.20	0.15
1972	36	0.27	0.16

Table 1. Density of breeding robins on Comox Burn, with respect to general habitat density, 1971-1972.

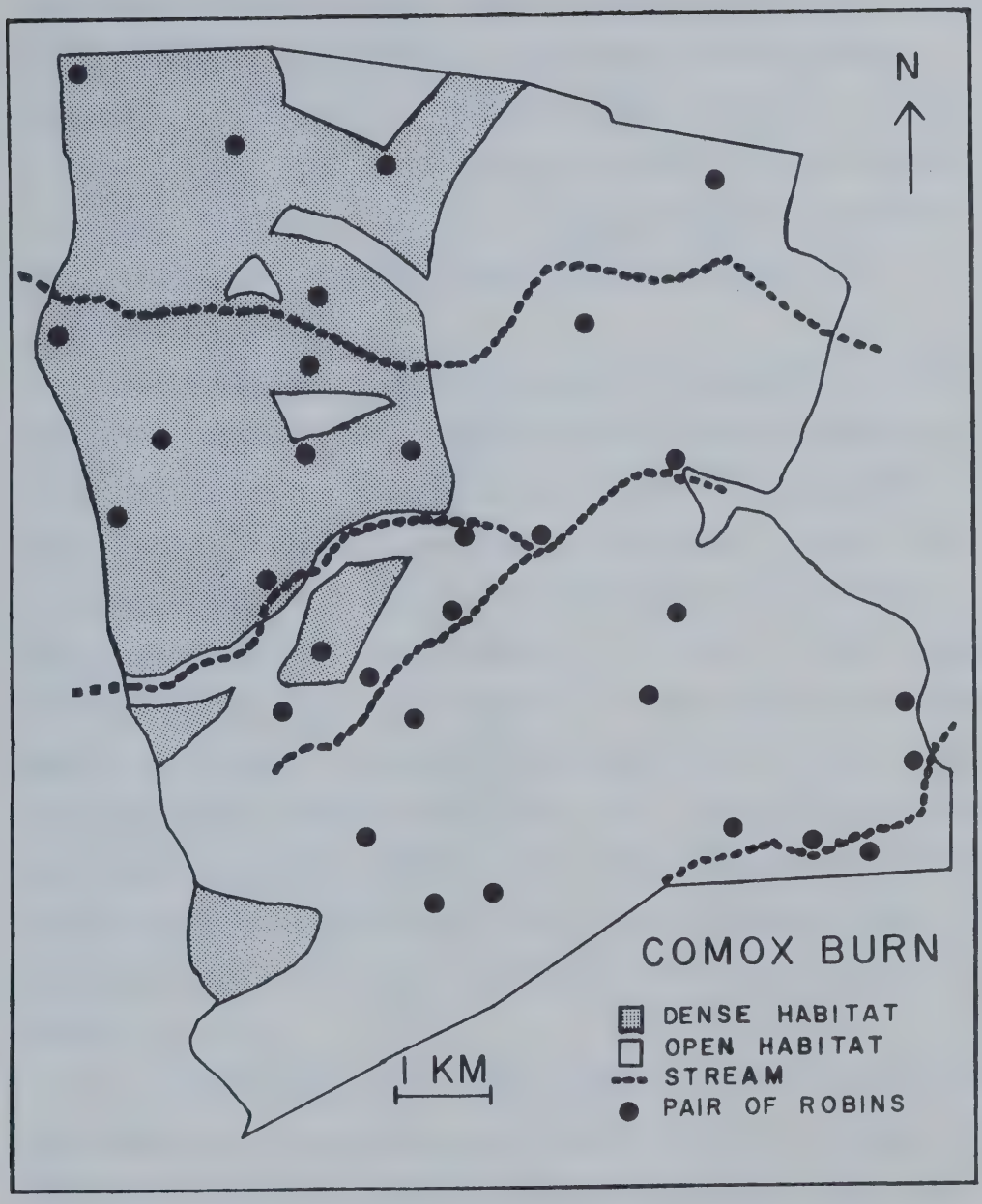


Figure 2. Distribution of pairs of robins on Comox Burn during the 1971 nesting season. Each circle represents the approximate centre of activity of one breeding pair.

even distribution in dense habitat and a clustering of pairs along streams in open habitat, with large areas here not utilized. In 1972, with a similar number of pairs to 1971 in open habitat, there was less of a clustered distribution. In dense habitat, the density of pairs slightly increased, but distribution remained rather uniform (Figure 3).

2. Annual mortality

Individually marking as many adults as possible, in 1971, gave some information on mortality and return of adults and juveniles in 1972. I caught only 14 adults representing 11 pairs in 1971. However, in 1972, 72 percent, or 10 of 14 returned (Table 2). Seven of eleven females and three of three males returned (see Appendix I). Farner (1949) computed the annual return of adult robins in urban areas to be approximately 50 percent. Although the sample size is small, the fact that all males returned indicates that a higher rate of return may occur in natural areas. Most robins returned to nests very close to the area utilized in 1971. One female provided an exception by moving over a ridge about 600 m from where she nested in 1971.

Thirty-five juveniles were banded in 1971 and 45 in 1972. Approximately one-third of the fledglings were resighted the same year (Table 3). Hence, one might postulate that about 30 percent survived to time of migration. No robins banded as juveniles in 1971 returned to the study area in 1972. Turdidae normally home relatively close to their place of birth (Werth, 1947). Juvenile survival was either low or no juveniles

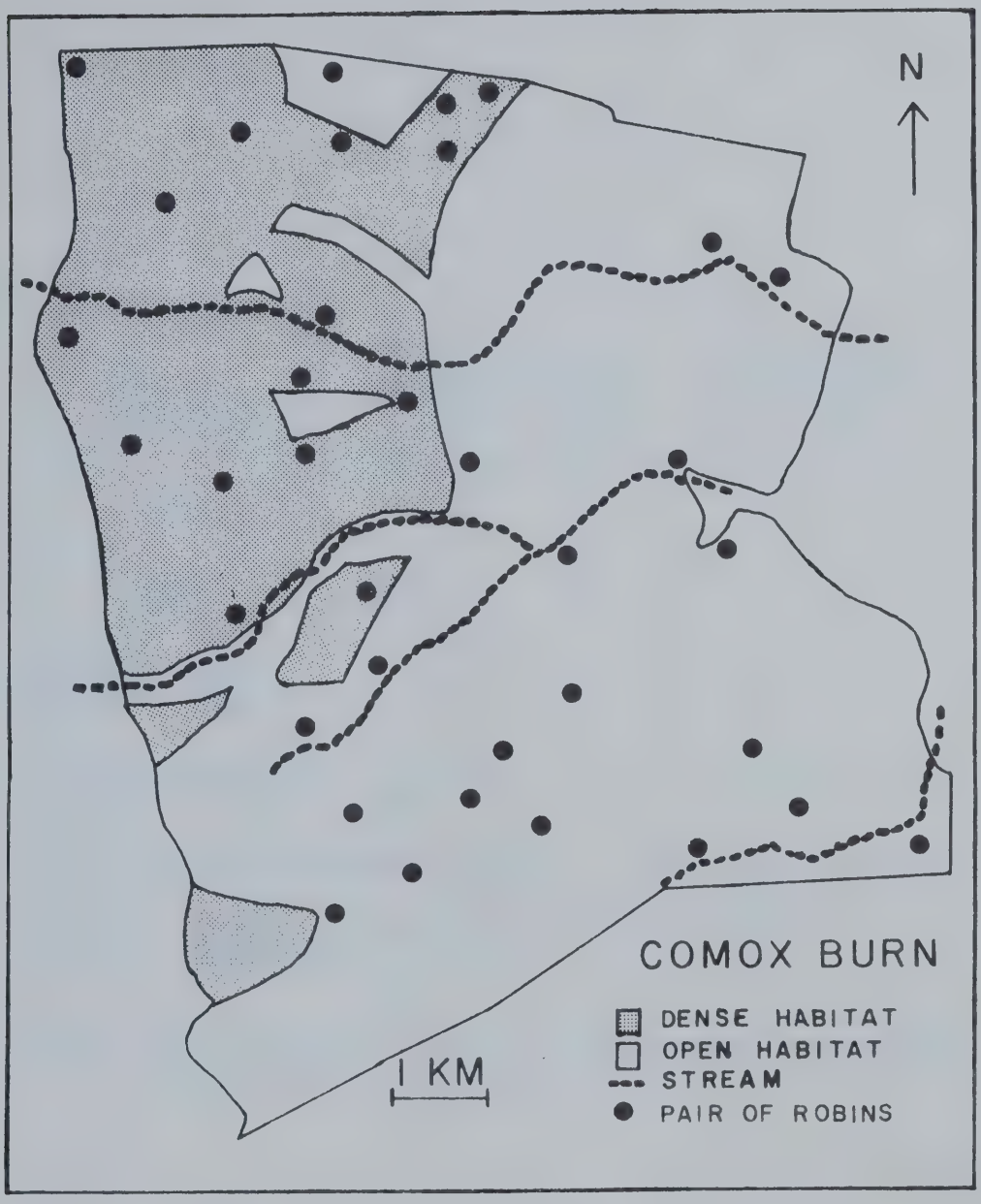


Figure 3. Distribution of pairs of robins on Comox Burn during the 1972 nesting season. Each circle represents the approximate centre of activity of one breeding pair.

YEAR OF BANDING	FEMALES	MALES	ALL ADULTS
1971	11	3	14
1972	18	8	26
Returned Adults Banded in 1971	7	3*	10
Total Banded Adults in 1972	25	11*	36

Table 2. Breeding adult robins banded on Comox Burn, 1971-1972.

* One male returned in late April but was never resighted during the nesting season of 1972.

YEAR	JUVENILES BANDED	BANDED JUVENILES SIGHTED ALIVE THE SAME YEAR n	%	BANDED JUVENILES RETURNED AS ADULTS
1971	35	11	31	-
1972	45	18	40	0
Total	80	29	36	0

Table 3. Juvenile robins banded on Comox Burn, 1971-1972.

returned to place of birth. As noted above, the population level appears to be stable or on a slight increase. With a high survival of adults, the population could withstand a low rate of survival of juveniles and still maintain itself.

3. Nesting parameters

The nesting parameters considered were incubation period, age of young at fledging, clutch size and number of nests built per pair. Incubation period was considered as the number of days elapsing between laying the last egg and hatching of the first nestling. Age of young at fledging refers to the number of days the young remained in the nest.

A comparison of nesting parameters can be made. In 1971, incubation and nestling periods were slightly longer than in 1972 (Table 4). This could be due to the greater amount of wet weather in 1971. Clutch size was normally three eggs. The slight increase in clutch size shown in Table 4, in 1972, is accounted for by several clutches of four eggs occurring in that year. In the two years, there was a difference in number of nests per pair (Table 4). In 1971, several pairs produced two successful nests. In 1972, the general trend was to produce one successful nest only. In several cases, there appeared to be ample time to raise another brood. A Student's 't' test does not reveal any significant differences between years for any of these parameters.

B. General habitat structure

1. Habitat description

The study area consists of 184 ha of which 59 (32

YEAR	MEAN INCUBATION PERIOD (Days)	MEAN AGE AT FLEDGING (Days)	MEAN CLUTCH SIZE	MEAN NUMBER OF NESTS/ PAIR
1971	13.3	13.5	2.98	2.5
1972	12.7	13.2	3.07	2.2

Table 4. Comparison of nesting parameters of robins on Comox Burn, between 1971 and 1972.

percent) were classified as dense and 125 (68 percent) as open. Results of the vegetation plot analysis are given in Table 5. Open areas had an average of 15 percent coniferous overstory cover and dense areas had approximately 40 percent . The habitat is far from uniform, although a certain degree of uniformity was imposed by planting Douglas-fir trees in rows. In both areas there was a wide range of cover. For instance, dense areas can have small open spots and open areas may have scattered dense clumps of trees resulting from natural regeneration of conifers. These areas do not significantly increase mean cover but greatly extend the range. A 't' test shows mean tree cover and mean total plot cover in dense and open areas for both 1971 and 1972 to be significantly different ($P < 0.01$). From 1971 to 1972, there was a significant increase in mean total plot cover in dense habitat ($P < 0.05$) and in open habitat ($P < 0.01$). Range in height of trees on the study area varied from less than one metre to greater than eight metres. By comparing mean tree height for both areas during 1971 and 1972 (Table 5), one can observe that trees in dense areas had a greater average annual growth than open areas. Mean tree height increased 0.90 m in dense and 0.20 m in open areas in one year.

2. Habitat utilization

Habitat, as classified, was one of two distinct structural types. There was a different density and distribution of pairs in the two types. One might predict that sizes of areas utilized while foraging or loafing would differ because of

YEAR		DENSE HABITAT TREE HEIGHT (metres)	DENSE HABITAT TREE COVER (sq.m)	DENSE HABITAT TOTAL PLOT COVER (sq.m)	OPEN HABITAT TREE HEIGHT (metres)	OPEN HABITAT TREE COVER (sq.m)	OPEN HABITAT TOTAL PLOT COVER (sq.m)
1971 n=30	$\bar{x}$	2.1	1.8	32.0	1.3	0.7	11.0
	range	1.7-2.7	1.3-3.6	16.4-56.9	0.8-2.5	0.3-1.8	2.2-28.0
1972 n=40	$\bar{x}$	3.0	2.6	50.4	1.5	1.1	18.8
	range	2.0-4.0	1.5-3.9	27.2-77.2	0.9-2.6	0.5-2.8	4.0-35.1

Table 5. Vegetation plot (10 m x 10 m) data describing general structure of habitat overstory on Comox Burn. Maximum "total plot cover" is 100 sq. m.

differences in overstory and ground cover. Sightings of banded individuals throughout the nesting season provided some data on this aspect. Insufficient data were obtained to calculate sizes of areas utilized by banded individuals. However, as an index to size of areas used, a mean latitude and a mean longitude were determined on a grid map using all sightings of an individual. Distance from this point to each sighting was recorded and an average value (mean activity radius) was calculated. This value gives some information as to whether individuals tend to conduct all of their activities close to a central spot (possibly a nest) or whether they travel long distances, perhaps to forage. Adults in dense habitat used a larger area and travelled longer distances than those in open areas. A mean activity radius of 151 m in dense habitat and 103 m in open habitat (Table 6) was found to be significantly different ($P < 0.02$) using a Mann-Whitney U test. Five males had a mean activity radius of 121 m and 17 females had a radius of 131 m. A Mann-Whitney U test did not reveal any significant differences in average distances travelled by the two sexes.

I recorded distances from the nest that banded juveniles were sighted (Table 7). Sightings were divided into those occurring less than 7 days, between 8 and 15 days and greater than 16 days post-fledging. In all age groups, juveniles fledging from nests in dense habitat were sighted further from the nest than those in open habitat. Although juveniles from dense habitats consistently moved further distances

GENERAL HABITAT	FEMALES NO.	FEMALES $\bar{x}$ ACTIVITY RADIUS (metres)	MALES NO.	MALES $\bar{x}$ ACTIVITY RADIUS (metres)	ALL ADULTS NO.	ALL ADULTS $\bar{x}$ ACTIVITY RADIUS (metres)
DENSE	8	160	4	131	12	151
OPEN	9	106	1	82	10	103

Table 6. Mean activity radius of banded adult robins on Comox Burn during 1971-1972. Mean activity radius was calculated from a centre of activity based on at least five sightings.

GENERAL HABITAT COVER	1 - 7 DAYS AFTER FLEDGING n	MEAN DISTANCE (metres)	8 - 15 DAYS AFTER FLEDGING n	MEAN DISTANCE (metres)	16+ DAYS AFTER FLEDGING n	MEAN DISTANCE (metres)
DENSE	6	192	7	410	12	481
OPEN	12	137	4	169	12	291

Table 7. Distances from the nest juveniles were sighted in relation to time from fledging (age) and general habitat cover. The number of sightings is given under the column headed 'n'. Mean distance is the average distance for all sightings of juveniles.

from the nest than those from open habitat, a Student's 't' test showed significance only in the 8 to 15 day age group ($P < 0.02$). Small sample sizes and wide ranges of values might account for the lack of significant differences in the other two age groups.

Pairs nesting in dense habitat tended to move to more open habitat with their juveniles. In 13 instances, banded juveniles were resighted more than twice; seven involved juveniles from nests in dense habitat and six from nests in open habitat. Five of seven juveniles from nests in dense habitat were resighted in open habitat. In the two remaining instances, juveniles from dense habitat were resighted only in dense habitat. All banded juveniles from nests in open habitat were resighted only in open habitat. Presumably, the move from dense to open habitat was related to a greater supply of berries and other foods in open areas.

C. Density and distribution of nests

Data on robin nests show that density and distribution of nests are by no means uniform. In 1971, 32 percent of all nests found occurred in dense habitat (32 percent of study area). In 1972, 48 percent of all nests occurred in this type (Table 8). In open habitat, the proportion decreased from 68 percent of the total nests (68 percent of study area) in 1971, to 52 percent of the total nests in 1972. Table 9 gives differences in densities , expressed as nests per hectare,between areas for both years. From Tables 8 and 9, one can see that density of total nests has remained the

GENERAL HABITAT COVER	SIZE OF AREA n	Hectares	%	1971 n	%	1972 n	%	1971-72 n	%
DENSE	59		32	24	32	48	48	74	42
OPEN	125		68	51	68	52	52	101	58
TOTAL	184		100	75	100	100	100	175	100

Table 8. Robin nests in dense and open habitats on Comox Burn, 1971-1972.

GENERAL HABITAT COVER	1971	1972
DENSE	.41	.82
OPEN	.41	.42

Table 9. Nests / hectare / season in dense and open habitat on Comox Burn, 1971-1972.

same from 1971 to 1972 in the open area. However, density of nests in the dense habitat has increased from 1971 to 1972. A Chi Square using Yates correction demonstrates no significant differences for nest density between the two areas in 1971, but a significant difference in 1972 ($P < 0.05$). Thus the dense habitat supported a greater density of pairs and nests than the open area in 1972, when compared to 1971. The greater density of nests may reflect either an increase in population numbers or a greater number of nests built per pair, or both.

If two habitats support different densities of nests, one may investigate their relative distributions. Figures 4 and 5 indicate differences in distributions of nests between areas and years. In 1971, nests in dense habitat were rather evenly spaced throughout the area. Nests in open areas tended to be distributed along major streams. In 1972, occurrence of nests on open areas did not exhibit such obvious clumping (Figure 5). Despite an increased density of nests in dense areas, in 1972, distribution tended to remain rather uniform. In both years, large areas of open habitat and smaller areas of dense habitat contained no nests, with robins seldom seen in these areas. The differences between years was due to a tendency of robins to nest along streams in 1971 but to do so to a lesser extent in 1972.

The distance of each nest to the neighbouring robin nest was measured. Using a distance to nearest neighbour test as described by Clark and Evans (1954), distributions

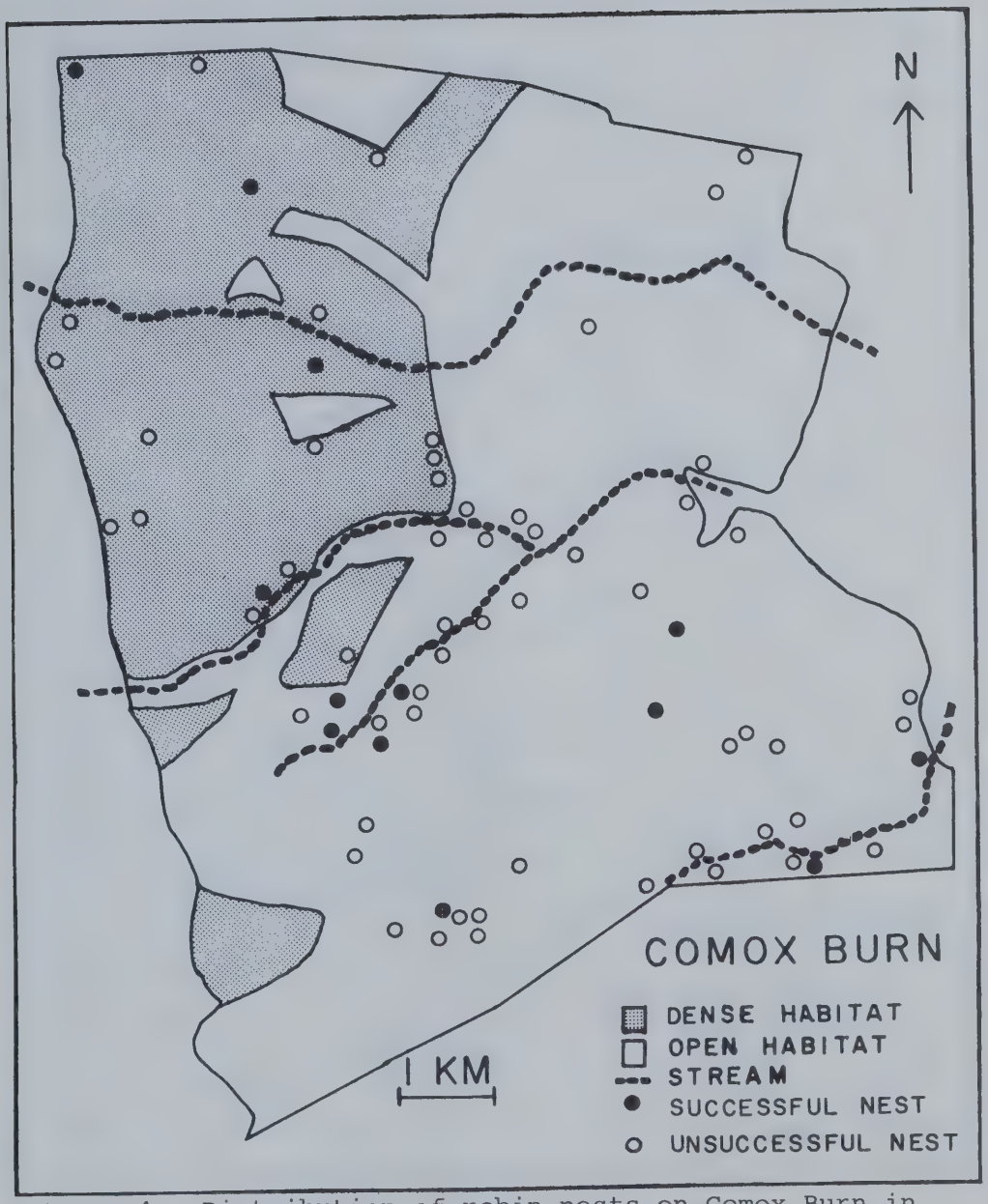


Figure 4. Distribution of robin nests on Comox Burn in 1971 with respect to nest success. Each circle represents one nest site. Active nests with unknown fates are not included.

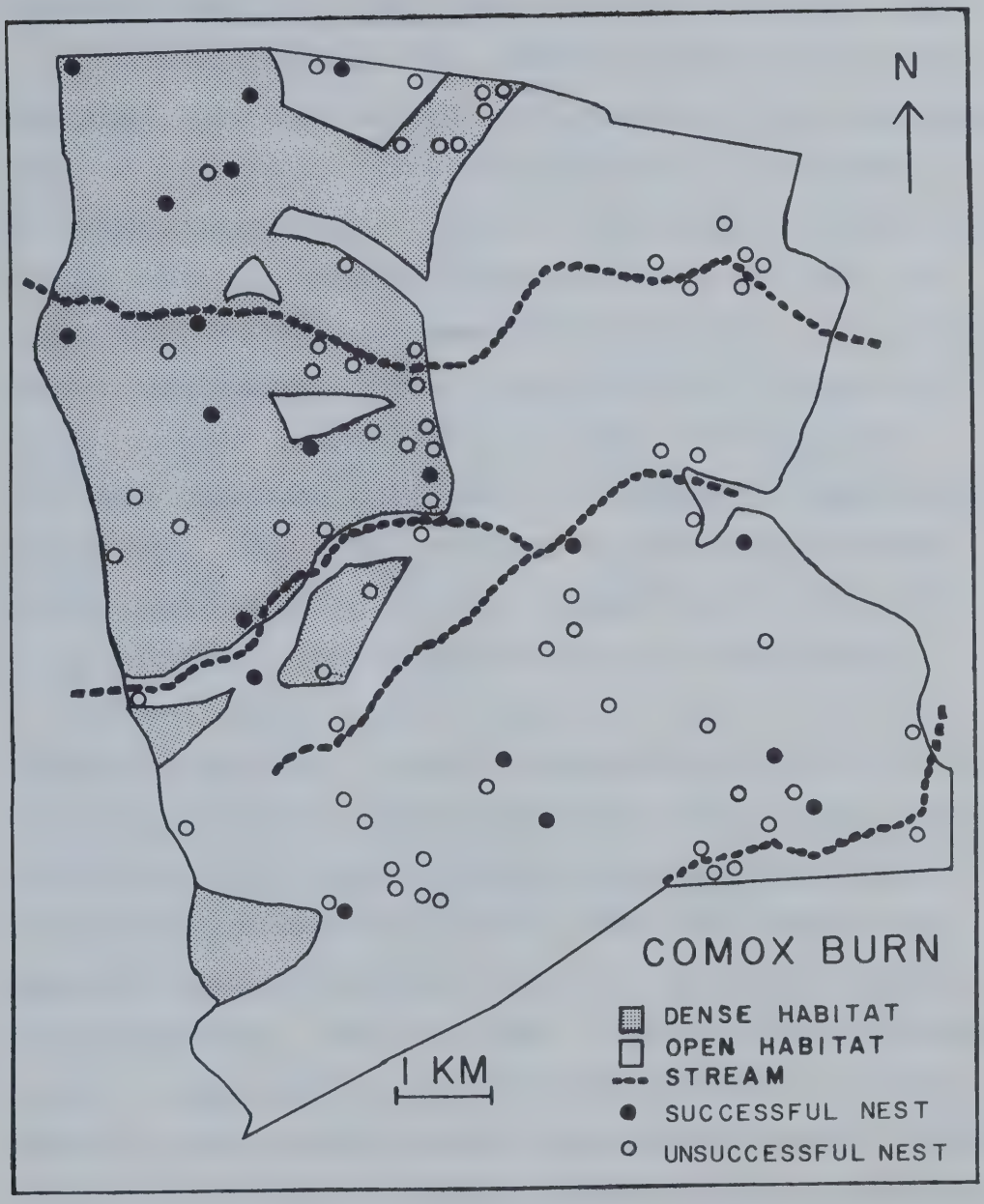


Figure 5. Distribution of robin nests on Comox Burn in 1972 with respect to nest success. Each circle represents one nest site. Active nests with unknown fates are not included.

of nests in dense and open habitat for both years were shown to differ significantly from a random distribution ($P < 0.01$). Open areas had a less uniform distribution of nests than dense areas in both years. Using the same data, one can detect differences in spacing of nests in both habitats. Mean distance between nests was computed for both areas in 1971 and 1972 (Table 10). In 1971, the mean distance between a nest and its nearest neighbour was 119 m in dense and 72 m in open areas. This difference proved to be significant ($P < 0.02$). In 1972, mean distances of 86 and 74 m for dense and open areas, respectively, were found to be not significantly different. Between years, spacing of nests in dense habitat was found to be different at the 90 percent level of significance.

One may validly argue that each nest site is not independent of any other. Actual differences in spacing between the two areas may be obscured by having several nests close together where one pair has been particularly unsuccessful. To test whether this was a serious bias, the exercise was repeated measuring distances from every nest to its nearest three neighbours. The same trend of nests being more widely spaced in dense habitat was exhibited (Table 11). A Mann-Whitney U test revealed similar differences to those obtained by using a 't' test for average distance to nearest neighbour except for the difference in mean distance between 1971 and 1972 in dense habitat. Considering mean distance to nearest three neighbours in dense habitat for 1971 and 1972, the

YEAR	DENSE HABITAT NO.OF NESTS	DENSE HABITAT $\bar{x}$ DISTANCE METRES	OPEN HABITAT NO.OF NESTS	OPEN HABITAT $\bar{x}$ DISTANCE METRES
1971	21	119	51	72
1972	44	86	49	74

Table 10. Average distances of nests to nearest neighbouring robin nests with respect to density of general habitat on Comox Burn, 1971-1972.

YEAR	DENSE HABITAT NO.OF NESTS	DENSE HABITAT $\bar{x}$ DISTANCE METRES	OPEN HABITAT NO.OF NESTS	OPEN HABITAT $\bar{x}$ DISTANCE METRES
1971	21	191	50	116
1972	44	126	49	119

Table 11. Average distance of any robin nest to three nearest neighbouring nests with respect to density of general habitat on Comox Burn, 1971-1972. Mean distance refers to an average distance to the three nearest nests.

differences were significant ($P < 0.02$). Hence, there was a greater spacing of nests in dense habitat than open, despite a higher density of nests in the dense areas. Both the Clark and Evans (1954) test and the spacing data indicate a more uniform distribution of nests in dense than in open areas.

D. Nest site characteristics

1. General characteristics

A robin has the largest and most conspicuous nest of any passerine on the study area, and the only nest with a mud bowl. The majority of nests were found in trees, but some occurred in ends of logs, upturned stumps and roots , and, rarely, on the ground. There does not appear to be any shortage of nest sites except possibly in some very open areas. Since robins indicate a willingness to nest in such a wide variety of sites, it is not probable that distribution of breeding pairs is limited by number and distribution of nest sites.

Most robin nests were found in Douglas-fir trees. This may represent availability rather than preference since Douglas-fir trees are the most abundant trees on the area. Robin nests generally occur on one of the lower branches, close to the trunk of the tree. In trees three to five metres high, robins do not have many alternatives as to where they place their nests. Nests in logs and stumps tended to be more exposed. The mean height of Douglas-fir trees containing active robin nests was 3.86 m in 1971 and 5.05 m in 1972. Heights of nests in trees increased from an

average of 0.83 m in 1971 to 1.03 m in 1972 (Table 12). This difference can probably be accounted for by annual growth of trees.

2. Consistency of individuals

Because of problems encountered in banding a large proportion of the breeding population in 1971, data on successive nests built by known individuals are rather sparse, but sufficient to show patterns. Over 83 percent of the females built successive nests with a difference in concealment rating of two or less (Table 13). Sixty-seven percent of females built nests which varied less than 50 cm in height. Since mean tree height on the study area was between three and five metres, there might not be a wide range of heights available. However, around the periphery of approximately one-half the study area and in scattered thickets throughout the area, there was opportunity to build nests at a range of heights. Seventy-five percent of the females consistently picked either open or dense vegetation at the nest site. This may be related to density of the general area, for if a pair chooses an area that has generally dense overstory, there is a high probability that vegetation immediately surrounding the nest site will be dense.

The low percentage of nests in stumps, logs or roots makes it difficult to draw conclusions about consistency of preferences for type of nest site. There was a greater tendency for robins to build nests in stumps and roots in open areas. In both cases where banded females built nests

LOCATION OF NEST	1971 NO.	1971 $\bar{x}$ HEIGHT (cm)	1972 NO.	1972 $\bar{x}$ HEIGHT (cm)
Douglas Fir	61	83	86	104
Other Conifers	5	98	2	205
Alders	2	83	1	40
Stumps, Logs, Roots or Ground	7	45	11	63
TOTAL	75	82	100	101

Table 12. Types of nest sites and mean nest heights on Comox Burn, 1971-1972.

BAND.NO. OF ADULTS	YEAR	SEX	TOTAL NO. OF NESTS	*** CONCEAL-MENT	NEST HEIGHT	DENSITY OF VEG. AROUND SITE		PROXIMITY TO WATER		TYPE OF SITE	
					Range (metres)	Dense n	Open n	<50m	>50m	Tree n	SLR** n
96405	1971-72	F	4	3,3,5,5	0.5-0.6	-	4	3	1	3	1
96468	1971-72	F	5	2,2,2,3	0.5-0.9	5	-	1	4	5	-
96417	1971-72	F	2	4,6	0.7-1.0	2	-	1	1	2	-
96418	1971-72	F	3	3,4,4	0.8	3	-	1	2	3	-
96438	1971-72	F	2	3,3	0.8-1.0	-	2	2	-	2	-
** 96404 96401	1971	F M	3	3,3,4	0.3-1.0	1	2	2	1	3	-
96414 96413	1971-72	F M	4	1,1,3,6	0.9-1.6	4	-	3	1	4	-
96406	1971	F	3	2,5,6	0.3-4.3	1	2	3	-	3	-
96430 96431	1971-72	F M	2	5,5	0.6	2	-	1	1	2	-
96500	1972	F	3	1,2,2	0.4-2.3	1	2	3	-	3	-
96319	1972	M	2	1,2	1.1-1.4	2	-	2	-	2	-
96313	1972	F	3	3,3,4	0.0-1.1	-	3	1	2	1	2

Table 13. Consistency of individuals in relation to nest site parameters.

* SLR - Stump, Log or Root

** Where two band numbers occur for one sighting a pair is represented.

*** Concealment rating refers to number of a possible six sides from which the nest was concealed (See page 14).

stumps, they built all of their nests in exposed nest sites in open areas.

E. Nest-search plots

A total of eleven robin nests were found while conducting a systematic nest-search on 40 plots. Of these, nine (both old and active) had been found in 1971. An old nest refers to one built previous to 1971. An active nest would have been built or reconstructed during 1971. Of the two which had not been found in 1971, one was on a dense area and one on an open area. The nest in open habitat occurred in a region of high nest density and could have been active in 1971. The nest in dense habitat was probably built during a summer previous to 1971 because I had, in 1971, complete nest data for all pairs in that region. Results of this search do not reveal a greater bias in my ability to find nests in either habitat type. An increased searching effort and an increased reliance on behaviour of adults seemed to have compensated for the greater problems of finding nests in dense areas.

While examining nest-search plots, I classified plots as to presence or absence of free water. Of 40 plots, 20 were dry, 5 contained part of a marsh, 10 had small streams running through them and 5 contained a section of a large stream. Since plots were picked randomly, they give an indication of the relative distribution and abundance of free water. If robins nested randomly with respect to proximity to water, then one would expect to find

approximately 50 percent of the nests within 50 m of a stream or marsh. These data will be referred to later when considering breeding success in relation to proximity of nests to free water.

F. Breeding success

1. Between years

A successful nest is one in which at least one young leaves the nest. The following figures and tables will have differing sample sizes for nests depending on the parameter being discussed. Because of the nature of the study, it was not possible to obtain complete data for every nest. For example, nests found in the nestling stage do not yield complete information about clutch size or average length of incubation. Some nests were active, but I was not able to ascertain whether they had been unsuccessful or successful. Such nests would be categorized "fate unknown".

In 1971, 194 nests were found on the study area, of which 75 were active during that season. Incubation was initiated in 55 of these nests. In 1972, 151 nests were found, of which 100 were active. Incubation was initiated in 65 nests. General nesting success for both years is summarized in Figure 6 and Table 14.

Nesting success between years was comparable. There was an increase in successful nests from 19 percent in 1971 to 22 percent of all nests used in 1972. Approximately equal percentages of unsuccessful nests were lost to predation and desertion each year. There was a slight decrease in the nests

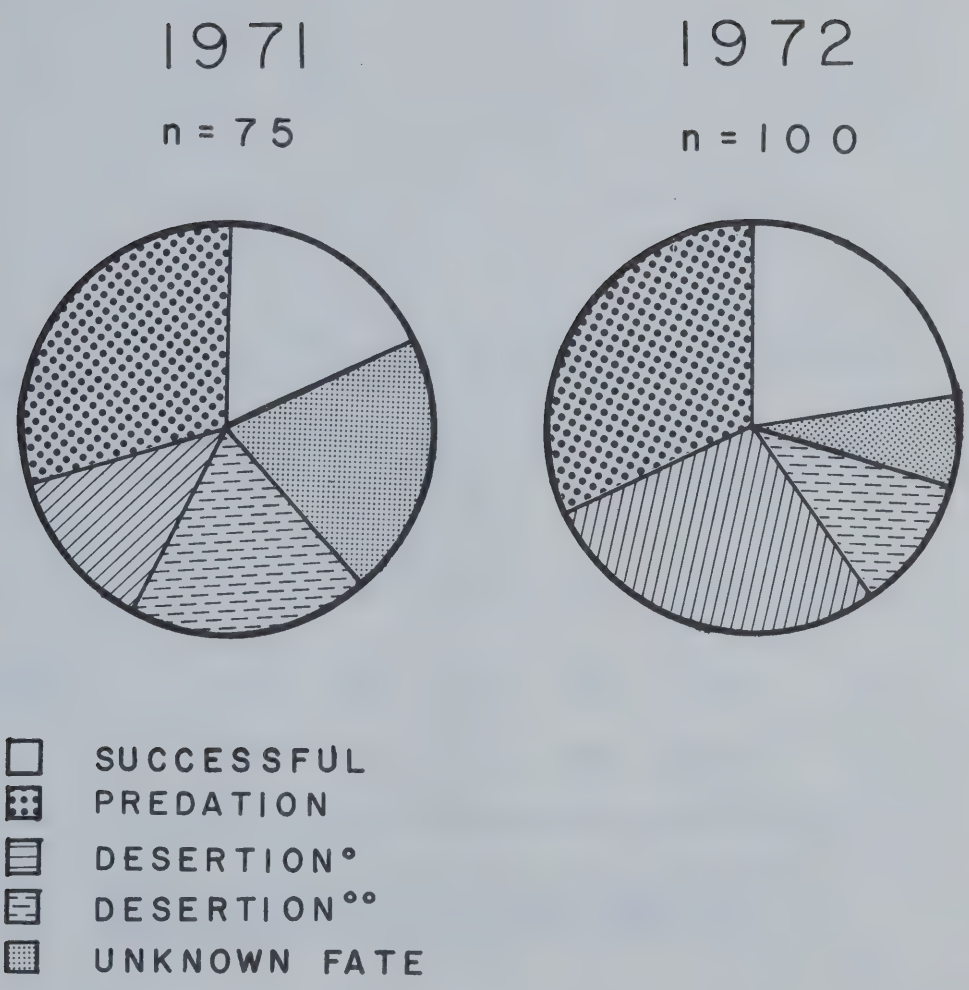


Figure 6. Schematic comparison of nesting success between 1971 and 1972, on Comox Burn.

° Before initiation of incubation
°° After initiation of incubation

FATE OF NEST	1971 NO.	1971 %	1972 NO.	1972 %	BOTH YEARS NO.	BOTH YEARS %
Successful	14	26	22	34	36	30
Predation	26	47	33	51	59	49
Desertion	15	27	10	15	25	21
TOTAL	55	100	65	100	120	100

Table 14. Fate of robin nests in which incubation was initiated on Comox Burn, 1971-1972.

with unknown fates from 1971 to 1972. The only major discrepancy between years concerned deserted nests when they were classified into those deserted before incubation was initiated and those after. There were no significant differences in nesting success between years except in the number of nests deserted before and after incubation was initiated ($P < 0.05$). The high rate of desertion during nest building in 1972 could be due to robins nesting earlier in that year, when nesting drive was probably not at its peak. Because I was more efficient at finding nests in the early season of 1972, compared to 1971, I may have caused some desertion of nests during the early building stage.

If one considers only those nests where incubation was initiated, 26 percent of the nests were successful in 1971 and 34 percent in 1972 (Table 14). In both years, about 50 percent of the nests were broken up by predators, predominantly mammals (see Appendix 2). Desertion dropped from 27 percent to 15 percent in the two years. More careful mistnetting and favorable weather during the breeding season of 1972 may account for this decrease. Chi Square tests revealed no significant differences between years in any of the above categories.

2. In relation to time of breeding season

Fates of nests throughout the breeding season show interesting differences between 1971 and 1972. In general, building, initiation of incubation, predation and successful fledging of juveniles from nests occurred regularly throughout

the season of 1971, but were separated into rather distinct time periods corresponding to first clutches, renests and second clutches in 1972.

In 1971, most young of successful nests fledged during late June to mid-July (Figure 7-A). Many unsuccessful nesting attempts were terminated during May with smaller numbers lost in mid-June and early July (Figure 7-B). In 1972, unsuccessful nesting attempts were terminated in two major time periods, May and mid-June to mid-July (Figure 8-B) with the latter period containing a smaller number. Most young were fledged from successful nests in 1972 during the first week in June and early July (Figure 8-A).

3. In relation to habitat structure

As discussed in an earlier section, dense habitat was found to have a higher density of nests than open habitat. Success of nests in each habitat gives information on relative advantages of nesting in the two areas. Data in Table 15 demonstrate the relationship between habitat structure and nesting success. In 1971, density of successful nests (approximately 0.07 nests per ha) and unsuccessful nests (approximately 0.30 nests per ha) was the same for open and dense habitat. In 1972, the situation remained similar to 1971 for open habitat. In dense habitat, density of total nests increased from 0.35 nests per ha in 1971 to 0.75 in 1972. As well, the ratio of successful to unsuccessful nests increased from 0.31 in 1971 to 0.42 during 1972, in dense habitat. There

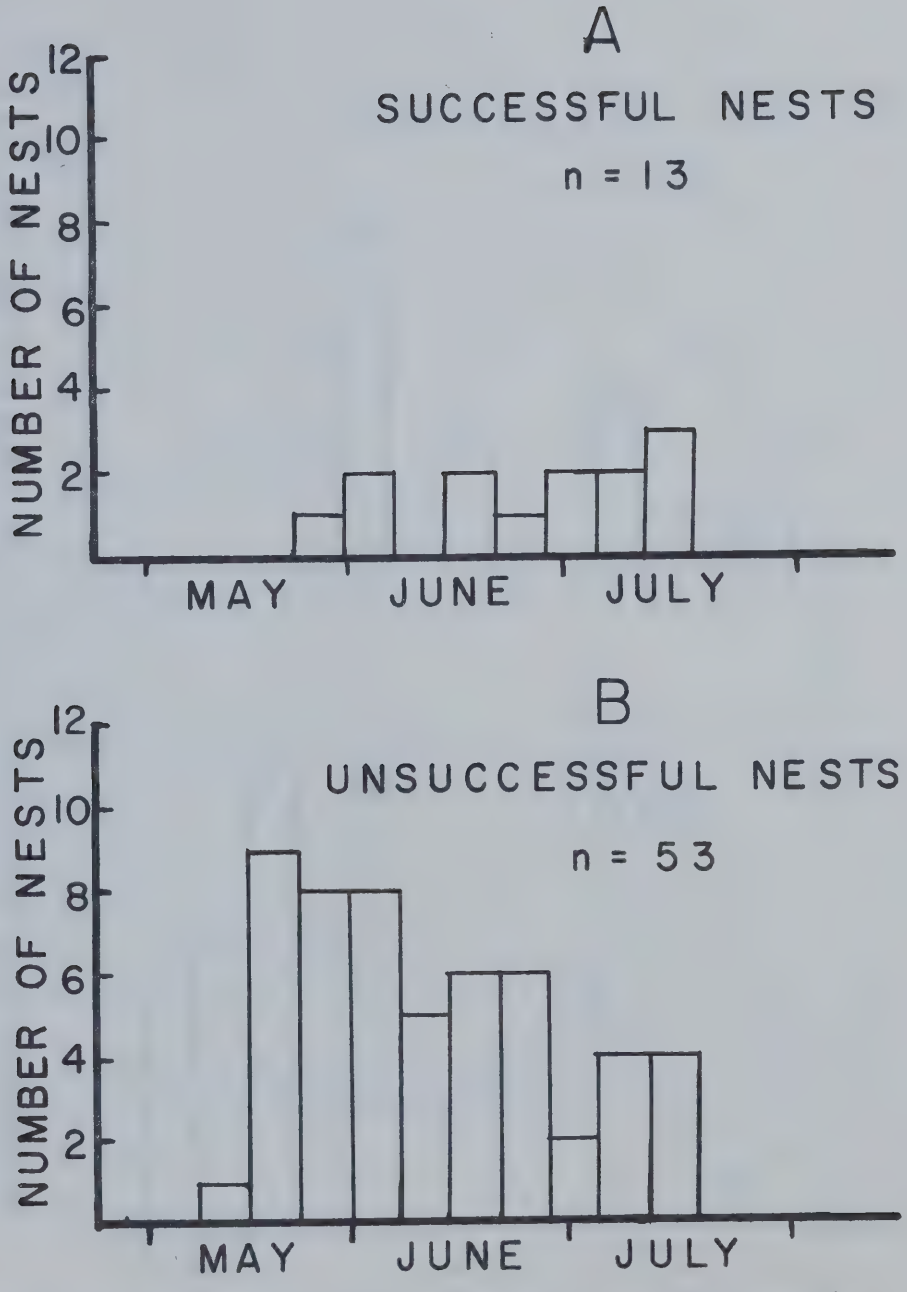
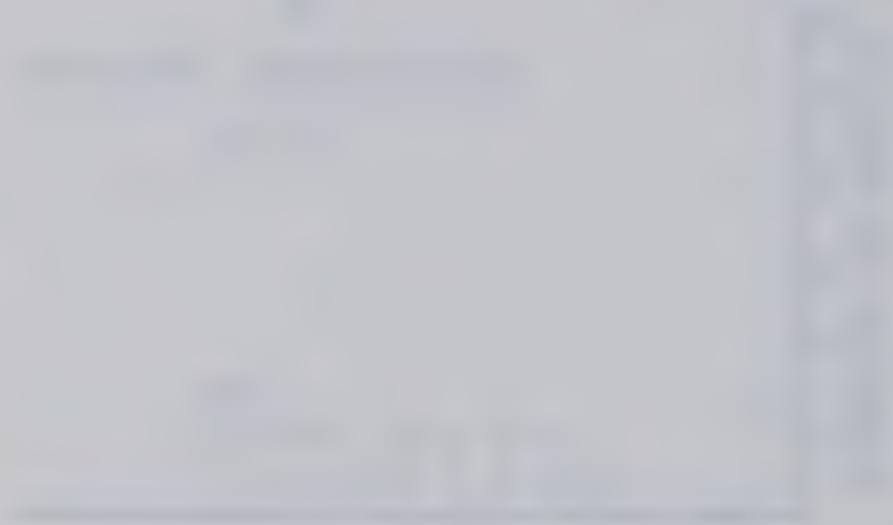


Figure 7. Fate of robin nests throughout the 1971 nesting season. Numbers of nests shown in each weekly interval represent those which were brought off successfully or were unsuccessful during that week.



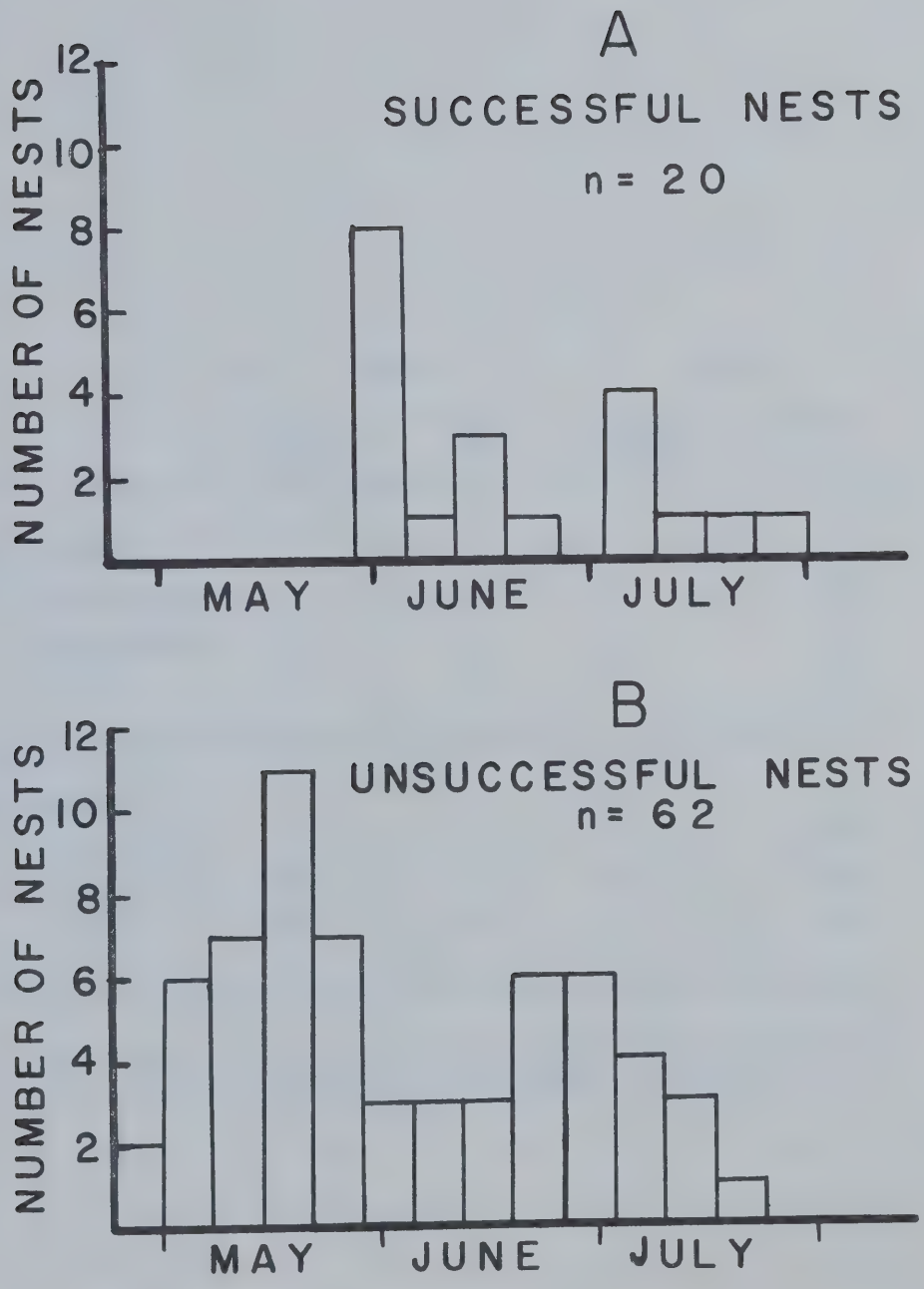


Figure 8. Fate of robin nests throughout the 1972 nesting season. Numbers of nests shown in each weekly interval represent those which were brought off successfully or were unsuccessful during that week.

	1971		1972	
	Total Nests	Nests/ ha	Total Nests	Nests/ ha
DENSE HABITAT				
Successful	5	.08	13	.22
Unsuccessful	16	.27	31	.53
TOTAL	21	.35	44	.75
OPEN HABITAT				
Successful	9	.07	8	.07
Unsuccessful	43	.34	45	.36
TOTAL	52	.41	54	.43

Table 15. Fate of robin nests in relation to density of general habitat on Comox Burn, 1971-1972.

were significant differences in densities of total nests between 1971 and 1972 ($P < 0.05$). In 1972, there was a significantly greater density of successful nests and total number of nests in dense habitat than in open ($P < 0.05$). Therefore, in 1971, there was no real advantage, in terms of breeding success, to nesting in either habitat, but in 1972, more nests were built and the proportion that had young successfully fledge was greater in dense habitat than in open habitat.

Small sample sizes, as shown in Table 15, may not reveal statistical differences. Data in this table and in a number of those following suggest consistent trends for nests with various fates, but significance is only revealed when sample sizes are large. This normally occurs when considering unsuccessful nests between years.

As well as considering the proportion of successful to unsuccessful nests in both habitats, one should consider overall production of young in both habitats. The nature of my study dictates that consideration of production refers only to juveniles successfully fledged.

In 1971, approximately equal numbers of juveniles were produced per nest built in dense and open habitat (Table 16). In 1971, numbers of juveniles produced per successful nest and those produced per nest built were not significantly different in the two habitat types. In 1972, equal numbers of young were produced per successful nest in both habitats. However, juveniles produced per nest built were 0.75 in dense habitat and 0.38 in open. A significantly greater number of

YEAR	DENSE HABITAT			OPEN HABITAT		
	TOTAL NESTS BUILT	NO. JUV./ NESTS BUILT	NO. JUV./ SUCCESSFUL NESTS	TOTAL NESTS BUILT	NO. JUV./ NESTS BUILT	NO. JUV./ SUCCESSFUL NESTS
1971	21	.43	1.8	52	.37	2.1
1972	44	.75	2.5	53	.38	2.5

Table 16. Juveniles fledged per nest built and per successful nest with respect to density of general habitat on Comox Burn, 1971-1972.

juveniles were produced per successful nest ($P < 0.05$) in dense habitat in 1972, when compared to 1971.

4. In relation to densities of nests

To determine relative densities of successful and unsuccessful nests in dense and open areas, the study area was divided into four-hectare units (an arbitrary size). In 1971, the densities of successful nests in dense and open areas were similar (Table 17). Unsuccessful nests had a much higher density in open than in dense habitat. Total nest density was greater in open areas than in dense areas in 1971.

In 1972, successful nests in dense areas were twice as numerous as in open. Unsuccessful nests had a similar density in the two habitat types. Total nest density was higher in dense than in open habitat.

Comparing years, densities of nests in open areas remained relatively constant for all nests. In dense areas, however, density of successful nests more than doubled from 1971 to 1972. Density of unsuccessful nests in 1972 also increased from 1971, but to a lesser extent.

In summary, densities of successful nests were similar in both habitats in 1971. Open areas had a higher density of unsuccessful nests than dense areas in 1971, and a similar density in 1972. In 1972, total nest density was similar to 1971, in open areas, but, increased markedly in dense areas. Chi Square analysis revealed no significant differences.

	DENSE HABITAT			OPEN HABITAT		
YEAR	SUCCESS-FUL NESTS	UNSUCCESS-FUL NESTS	TOTAL NESTS	SUCCESS-FUL NESTS	UNSUCCESS-FUL NESTS	TOTAL NESTS
1971	.25	.94	1.19	.28	1.41	1.69
1972	.63	1.50	2.13	.31	1.41	1.72

Table 17. Density of robin nests of a specific fate with respect to general habitat on Comox Burn, 1971-1972. Density of nests is expressed as nests per four-hectare unit.

5. In relation to distribution of nests

As discussed earlier, dense and open areas did not have nests distributed in the same pattern. Dense areas tended to have nests uniformly distributed, whereas open areas had a clustered distribution. Nests of a specific fate may have different distributions according to habitat type. By graphing the frequency of nests with a specific fate occurring in a four-hectare unit, one can obtain information on the distribution of nests as related to nesting success.

The distributions of successful nests in dense and open habitat are demonstrated in Figures 9 and 10. In 1971, 75 percent of the units in dense habitat contained no nests. The remaining units each contained one nest (Figure 9-A). In open habitat, 81 percent of the units contained no nests and the remainder contained equal numbers of units of one and two nests (Figure 9-B). In 1972, in dense habitat about equal numbers of four-hectare units contained one and no nests (Figure 10-A). In open habitat, a high proportion of units contained no nests and a much lower portion contained one or two nests (Figure 10-B). In both years, there was a tendency for successful nests to be evenly distributed in dense habitat and exhibit some clustering in open habitat. Relatively small numbers of successful nests made it difficult to show conclusive differences between the habitat types.

In 1971, most four-hectare units contained one or no unsuccessful nests (Figure 11-A) in dense habitat. Open areas had a large proportion of units with no nests and an

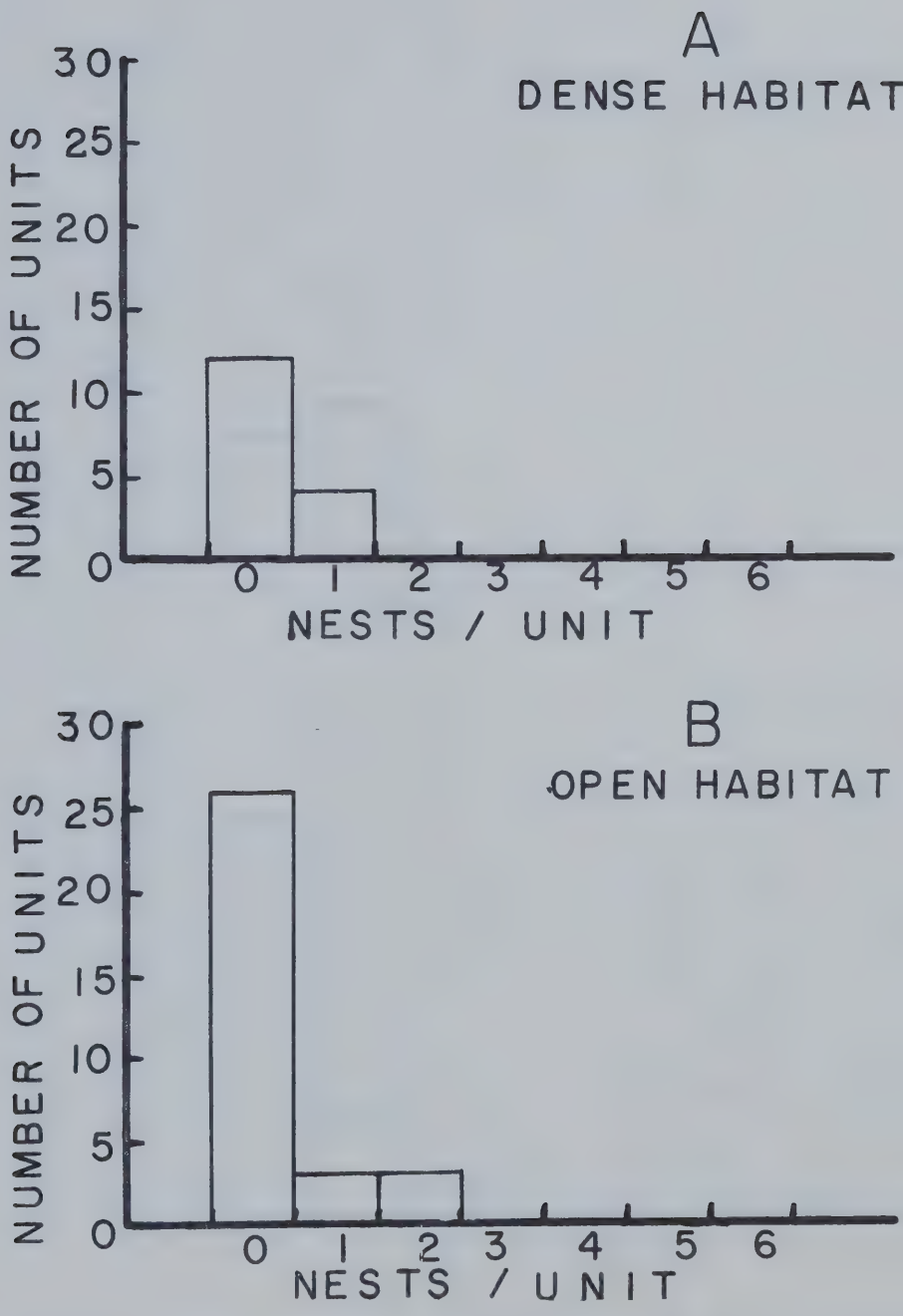


Figure 9. Numbers of nests per four-hectare unit in which robins were successful in dense and open habitat, 1971. In dense habitat, n = 16 units; in open, n = 32 four-hectare units.

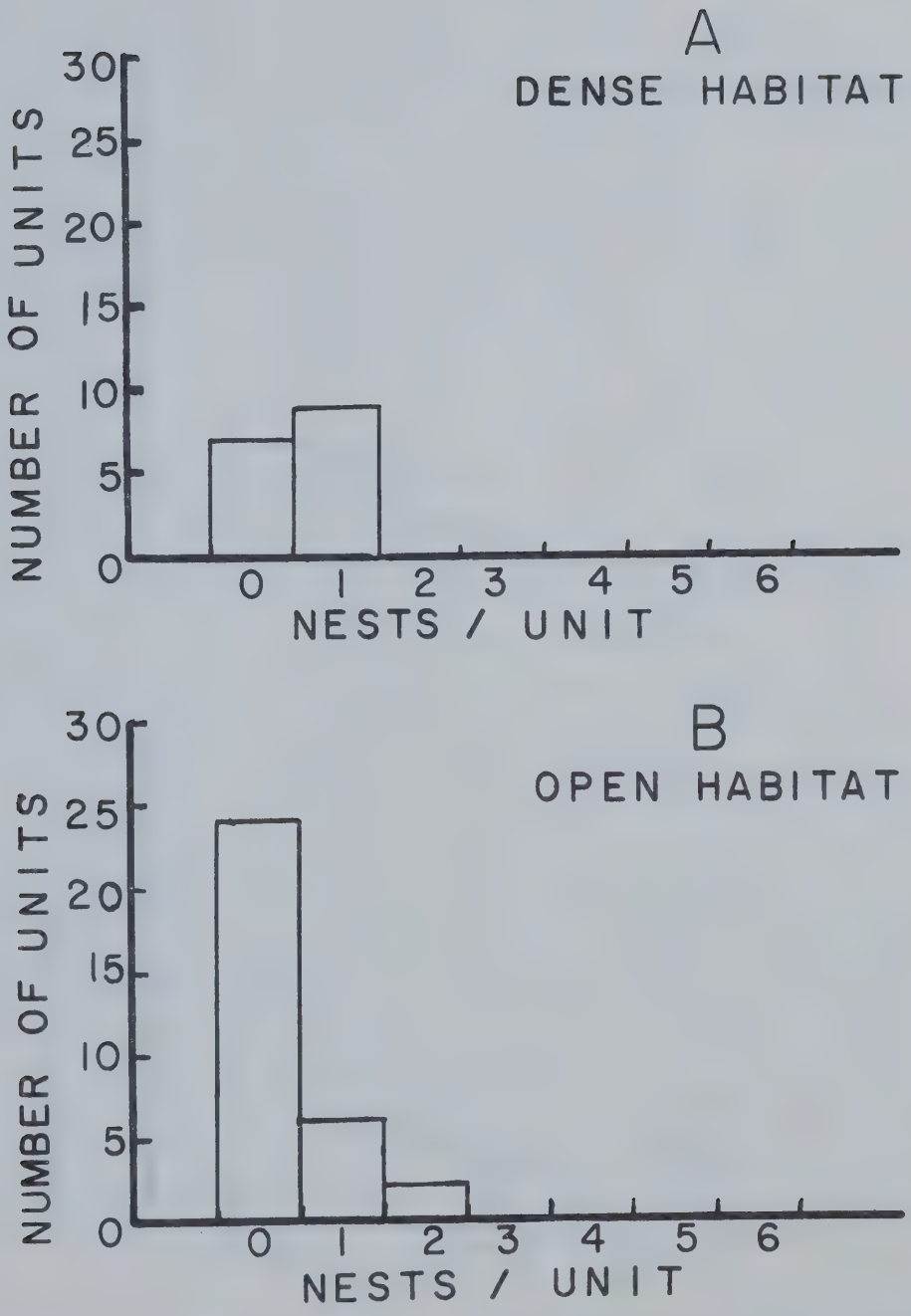


Figure 10. Numbers of nests per four-hectare unit in which robins were successful in dense and open habitat, 1972. In dense habitat, n = 16; in open, n = 32.

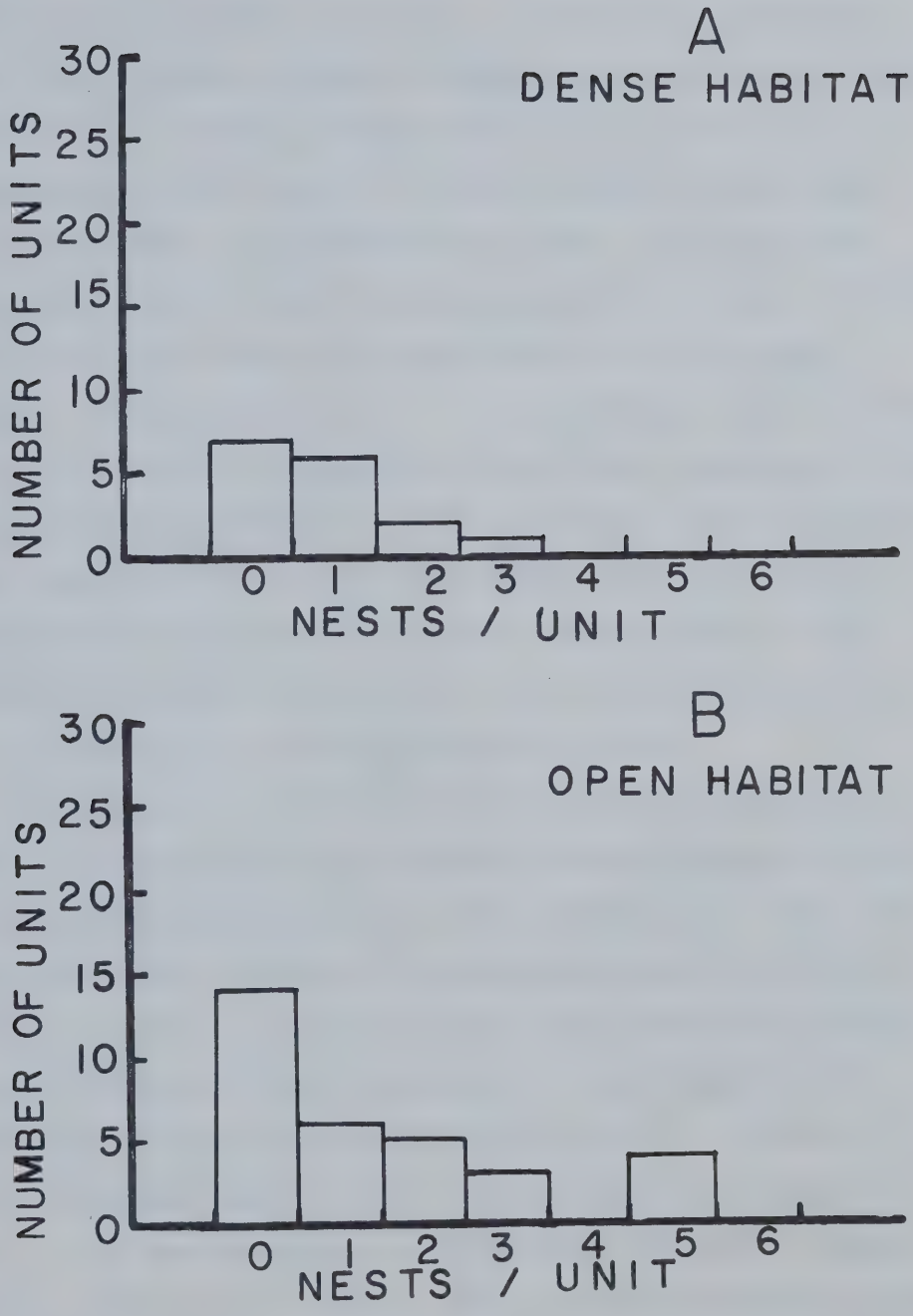


Figure 11. Numbers of nests per four-hectare unit in which robins were unsuccessful in dense and open habitat, 1971. In dense habitat, n = 16; in open, n = 32.

equivalent number with one, two or three nests per unit (Figure 11-B). In addition, there were four high-nest-density units, with five nests per unit. In 1972, distributions of unsuccessful nests in dense and open areas were rather similar (Figure 12). In both habitat types, the majority of units contained one or no nests. A lesser proportion contained two, three, four, or five nests per unit. In dense overstory, the ratio of units containing one or no nests to those containing high densities of nests was 11 : 5; in open habitat, the ratio was 19 : 3. On the whole, nests occurred uniformly throughout dense habitat and had a tendency to occur in clumps in open habitat. Both successful and unsuccessful nests seemed to follow the above trend. A greater sample size would be required to ascertain whether there is any relationship between distribution and success of the nest.

6. In relation to nest site characteristics

In addition to considering general habitat structure, I chose to investigate relationships between breeding success and nest site characteristics. Relationships of mean cover, mean nest height, density of vegetation around the nest site and type of site to success of nest are summarized in Table 18. In both years, mean concealment rating tended to be higher in successful than unsuccessful nests. In 1972, mean concealment for all nests was lower by 0.4 than in 1971. A 't' test applied to concealment values for successful and unsuccessful nests in 1971 and 1972 and between years did not demonstrate any significant differences ($P > 0.05$).

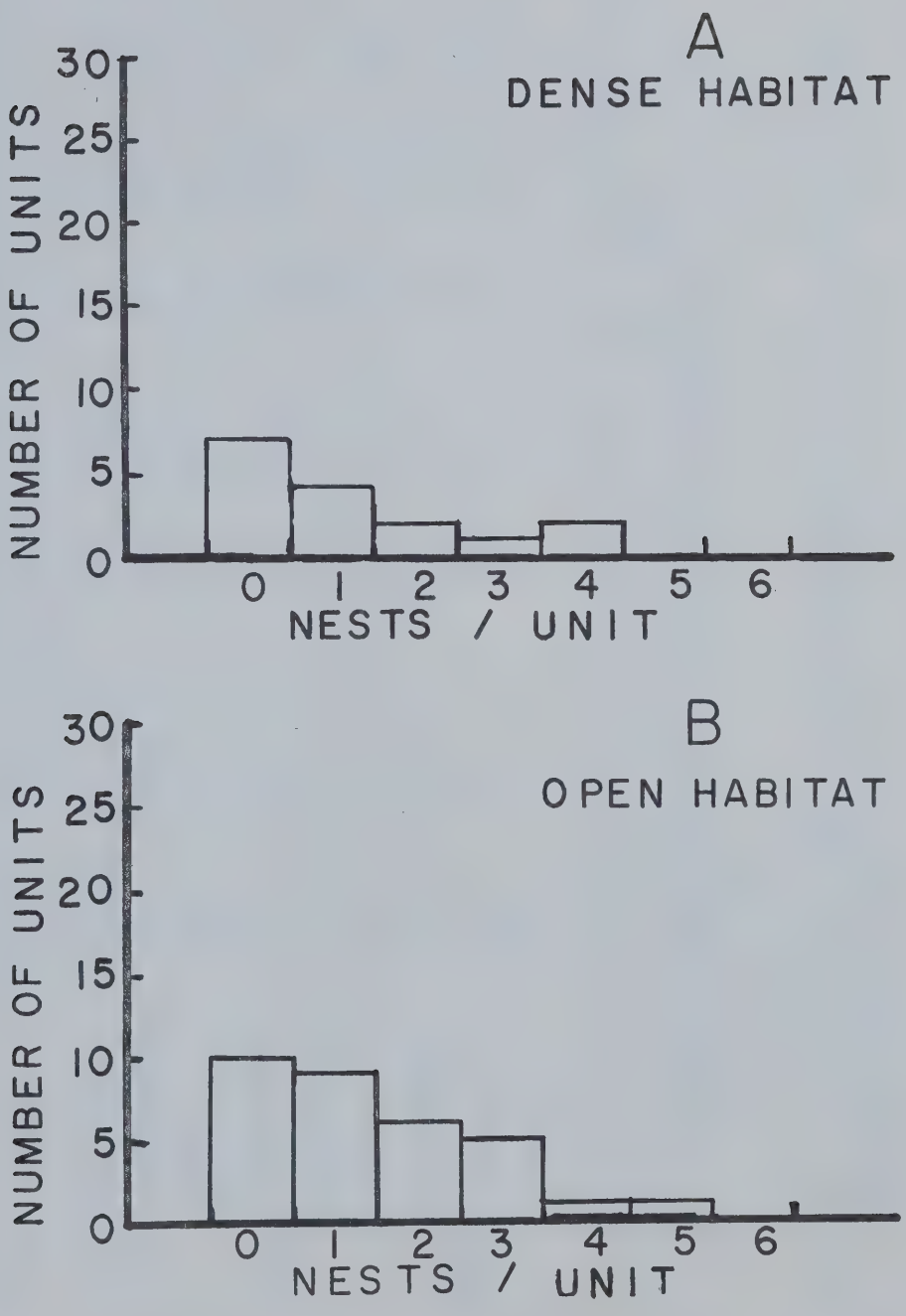


Figure 12. Numbers of nests per four-hectare unit in which robins were unsuccessful in dense and open habitat, 1972. In dense habitat, n = 16; in open, n = 32.

YEAR	FATE OF NESTS	NO.OF NESTS	MEAN CONCEALMENT RATING**	MEAN NEST HEIGHT (metres)	DENSITY OF VEG. AROUND NEST SITE		TYPE OF SITE	
					Dense No.of Nests	Open No.of Nests	Tree No.of Nests	SLR* No.of Nests
1971	Successful	14	3.9	1.03	9	5	13	1
	Unsuccessful	52	3.5	.82	20	32	49	3
	TOTAL	66	3.6	.87	29	37	62	4
1972	Successful	22	3.4	.99	10	12	19	3
	Unsuccessful	71	3.1	1.01	31	40	64	7
	TOTAL	93	3.2	1.00	41	52	83	10
Both Years	Successful	36	3.5	1.00	19	17	32	4
	Unsuccessful	123	3.3	.93	51	72	110	10
	TOTAL	159	3.3	.95	70	89	145	14

Table 18. Nest site parameters related to the fate of robin nests. Density refers to quality of vegetation immediately around the nest site.

* SLR - Stump, Log or Root

** Concealment rating is expressed as the number of sides concealed out of a possible rating of six.

Although average height of all nests increased 0.13 m from 1971 to 1972, average height of successful nests decreased from 1.03 m in 1971 to 0.99 m in 1972. Average height of unsuccessful nests increased from 0.82 m in 1971 to 1.01 m in 1972. None of these differences was significant.

Density of vegetation within a three-metre radius of the nest site was determined using the same criteria as for general habitat structure (i.e., height and survival rating of trees). In both years, the majority of successful nests had dense vegetation immediately surrounding the site, whereas the majority of unsuccessful nests occurred in open sites (Table 18). Chi Square demonstrated no significant differences ($P > 0.05$).

Information on distribution and abundance of free water (marsh or stream) was presented in the section, Nest-search plots. If robins nested randomly with respect to free water, one would expect approximately one-half of the nests to occur less than 50 metres from free water. In 1971, about 80 percent of all nests occurred less than 50 m from a stream or marsh. In 1972, 72 percent were in this category (Table 19). This difference was highly significant ($P < 0.001$).

Since robins select sites near streams and marshes, I decided to see if proximity to water had any effect on nest success. Approximately equal percentages of successful and unsuccessful nests in 1971 occurred farther than 50 m from free water. In 1972, 41 percent of successful and 24 percent of unsuccessful nests were situated further than 50 m from

YEAR	FATE OF NESTS	NO. OF NESTS GREATER THAN 50m n	%	NO. OF NESTS LESS THAN 50m n	%	MEAN DISTANCE OF NESTS FROM FREE WATER NESTS LESS THAN 50m
1971	Successful	3	21	11	79	11.2
	Unsuccessful	10	19	42	81	14.9
	TOTAL	13	20	53	80	14.1
1972	Successful	9	41	13	59	20.8
	Unsuccessful	17	24	54	76	14.6
	TOTAL	26	28	67	72	15.8
Both Years	Successful	12	33	24	67	16.4
	Unsuccessful	27	22	96	78	14.7
	TOTAL	39	25	120	75	15.0

Table 19. Fate of robin nests related to proximity to free water. The mean distance from nest to free water includes only those nests less than 50 m from a stream or marsh.

free water. In 1971, of all nests occurring less than 50 m (close) from free water, successful nests were closer to water than unsuccessful nests. In 1972, the reverse occurred. Successful nests in the "close" category had a mean distance of 20.8 m from water while unsuccessful nests had a mean distance of 14.6 m from free water. None of these differences was significant ($P > 0.05$).

There was no significant difference in concealment between successful and unsuccessful nests. Observations indicated that nests occurring in locally dense vegetation were generally not well concealed in the tree or stump. Successful nests in locally open vegetation were usually well concealed. This points to a possible relationship between specific concealment of a nest and density of vegetation around the site. A nest in dense vegetation probably requires less concealment than a nest in open vegetation.

In 1971, five successful nests had light concealment (concealment rating from one to three) and nine had heavy concealment (rating from four to six). Of the five with light concealment, three occurred in dense vegetation (Table 20). Of the nine successful nests having heavy concealment, six were in dense vegetation. Of 50 unsuccessful nests, 25 had light concealment, of which 18 occurred in open vegetation. Of the remaining 25 nests with heavy concealment, approximately equal numbers occurred in both densities of vegetation. In 1972, the same trends occurred except for slightly more nests surrounded by dense vegetation (Table 21). Successful nests

FATE OF NESTS	TOTAL NESTS	%	CONCEALMENT RATING	OPEN VEGETATION No.	%	DENSE VEGETATION No.	%
Successful n = 14	5	36	1-3	2	40	3	60
	9	64	4-6	3	34	6	66
Unsuccessful n = 50	25	50	1-3	18	72	7	28
	25	50	4-6	13	52	12	48

Table 20. Relationships between concealment and density of vegetation immediately around the nest site with respect to fate of robin nests on Comox Burn in 1971. Concealment was rated on a scale from one to six.

FATE OF NESTS	TOTAL NESTS	%	CONCEALMENT RATING	OPEN VEGETATION No.	%	DENSE VEGETATION No.	%
Successful n = 22	8	36	1-3	3	38	5	62
	14	64	4-6	9	64	5	36
Unsuccessful n = 69	41	59	1-3	19	46	22	54
	28	41	4-6	19	50	9	50

Table 21. Relationships between concealment and density of vegetation immediately around the nest site with respect to fate of robin nests on Comox Burn in 1972. Concealment was rated on a scale from one to six.

were not significantly more concealed or surrounded by dense vegetation than were unsuccessful nests, if Chi Square and "G" tests were applied to the data. Likewise, unsuccessful nests were not significantly more abundant in open, exposed sites than were successful nests ($P > 0.05$). The effects of concealment of nests and density of vegetation around the site on nest success are probably obscured by small sample sizes. To overcome this problem, I considered nests as either vulnerable or invulnerable. A vulnerable nest would occur in an exposed site in open vegetation. An invulnerable nest would occur in dense vegetation or in open vegetation with heavy concealment. In 1971, only 2 of 14 successful nests were vulnerable whereas 18 of 50 unsuccessful nests were so classified (Table 20). In 1972, only 3 of 22 successful nests were in vulnerable sites, whereas, 19 of 69 unsuccessful nests were in vulnerable nest sites (Table 21). Combining data for both years, 5 of 36 successful nests and 36 of 119 unsuccessful nests occurred in vulnerable sites (Table 22). The relationships for 1971, 1972 and 1971-1972 combined, between nest success and vulnerability were different at the 70, 80 and 90 percent levels of significance, respectively.

If concealment and density of vegetation around the nest site have an effect on success of the nest, then one might expect to have successful and unsuccessful nest sites. A successful or unsuccessful nest site would be one in which the nest built in the site tended to be consistently

FATE OF NESTS	TOTAL NESTS	%	CONCEALMENT RATING	OPEN VEGETATION No.	%	DENSE VEGETATION No.	%
Successful n = 36	13	36	1-3	5	38	8	62
	23	64	4-6	12	52	11	48
Unsuccessful n = 119	66	55	1-3	36	55	30	45
	53	45	4-6	32	60	21	40

Table 22. Relationships between concealment and density of vegetation immediately around the nest site with respect to fate of robin nests on Comox Burn, 1971-1972. Concealment was rated on a scale from one to six.

successful or unsuccessful in having young fledged from it. On my study area, the number of reused nest sites was rather small. A reused nest site was considered as one where a nest was rebuilt or merely relined, where another nest was built on top of an old nest, or where an old nest had fallen out of a tree and a female (not necessarily the same one) built another nest in its place. One successful nest site in 1971 was successful in 1972. Four unsuccessful sites in 1971 were subsequently unsuccessful in 1972 (Table 23). Nests built previous to 1971, but found in that year only give information as to rate of reuse of nest sites. Four sites of old nests found in 1971 and reused in 1972 resulted in one successful and three unsuccessful nests in 1972. This ratio probably reflects the general nesting success of the area. Although these data are quite limited, there appear to be successful and unsuccessful sites.

7. In relation to individual pairs

With color banded individuals, data can be gathered about nesting habits of individuals. If nesting success is low on Comox Burn, what patterns of failure exist? The role of general habitat structure and nest site characteristics has already been presented. There may be two types of breeding birds on the area: successful and unsuccessful birds; this may or may not be related to habitat type chosen. Table 24 contains a summary of available information on 12 pairs having successive nests. There is a general trend towards success or lack of it. Ignoring the instance in which mistnetting caused

NEST SITE USED PREVIOUS TO OR DURING 1971		NEST SITE REUSED IN 1972	
Fate of Nest	No.	Fate of Nest	No.
Successful	1	Successful	1
Unsuccessful	4	Successful Unsuccessful	0 4
Old	4	Successful Unsuccessful	1 3

Table 23. Fate of robin nests in sites found in 1971 and reused in 1972 on Comox Burn.

BAND. NO. OF ADULTS	SEX	YEAR	TOTAL NO. OF NESTS BUILT	NO. OF SUCCESSFUL NESTING ATTEMPTS	NO. OF UNSUCCESSFUL NESTING ATTEMPTS
96405	F	1971-72	4	3	1
96468	F	1971-72	5	1	4
96417	F	1971-72	2	2	0
96418	F	1971-72	3	2	1
96438	F	1971-72	2	2	0
96401***	M	1971	3	1	2
96404	F				
96413	M	1971-72	4	3	1*
96414	F				
96406	F	1971	3	0	3
96430	M	1971-72	2	1	1**
96431	F				
96500	F	1972	3	0	3
96319	M	1972	2	1	1
96313	F	1972	3	0	3*

Table 24. Consistency of nesting success for individual robins on Comox Burn, 1971-1972.

* I caused a desertion.

** Female killed in predation.

*** Two band numbers in a single example represent a pair.

a desertion, almost one-half of the pairs were either totally successful or unsuccessful. Three pairs having four or more nests were successful or unsuccessful with the exception of one nest. The data were necessarily biased in favor of successful individuals since it was necessary for them to bring the nest to a stage where there were young nestlings before there was an opportunity to catch and mark them. In a few instances, when I could ascertain with some confidence the fate of nests belonging to unbanded robins, the same trends appeared. In two instances, unbanded females built four nests and did not succeed in bringing one past the incubation stage. Robins on Comox Burn appear to be successful or unsuccessful, generally, but samples were too small for statistical validation of this conclusion.

8. In relation to other studies

Since robins are able to maintain populations in both natural areas and areas greatly modified by man, I considered it worthwhile to compare nesting success in both areas. Most published studies on nesting success of robins took place in urban areas around universities, cemeteries, gardens and towns. These studies sometimes include data only from nests where incubation was initiated. Success in urban areas tended to be high. Kendeigh (1942) reported 78 percent success of 501 nests in Illinois and,generally, nesting success ranges from 60 to 80 percent for robins in urban areas (Table 25). Hester (1964) from Massachusetts provided one exception to this generalization. He found 44 percent nest success on the

TOTAL NESTS	NO. OF SUCCESSFUL NESTING ATTEMPTS	% NEST SUCCESS	SOURCE	LOCATION
501	390	78	Kendeigh, 1942	Illinois, U. S. A.
136	83	61	Howell, 1942	Ithaca, New York, U. S. A.
64	49	77	Koehler, 1945	Madison, Wisconsin, U. S. A.
16	2	13	Thomsen, 1944	Wisconsin, U. S. A.
176	86	49	Young, 1955	Madison, Wisconsin, U. S. A.
53	31	59	Kemper, 1971	Vancouver, B. C.
307	186	61	Nest records°	Prov. of B.C., 1955-69
67	62	92	Horvath, 1963	Hope, B. C.
72	32	44	Hester, 1964	Area 1,* Amherst, Mass. U. S. A.
23	6	26	Hester, 1964	Area 2,** Amherst , Mass. U. S. A.
175	36	21	Present Study, 1971-72	Comox Burn, Vancouver Island, B. C.

Table 25. Nesting success of robins in urban areas of Canada and the United States as compared to Comox Burn.

* Areas associated with human activity

** Areas disassociated with human activity.

° British Columbia Nest Records Scheme.

University of Massachusetts campus.

Data from the British Columbia Nest Records Scheme showed 61 percent nest success of 307 nests from 1955 to 1969, most of which were from urban areas. Kemper (1971) in Vancouver, British Columbia, found 59 percent of all nests built were successful. This compares with an overall success rate of 21 percent on Comox Burn. Horvath (1963) found a high rate of nest success in robins at the Thacker Ecological Research Station at Hope, British Columbia, an area which may be considered "semi-natural". The high success rate there may have been related to position of the nest and nest height. Most nests occurred in crowns of tall dense trees. A study on nesting success was not his major concern, consequently he found 97 nests over a two year period and determined the fate of only 67 (70 percent). Possibly, nests with unknown fates were less successful.

Hester (1964) found a lower nesting success of robins (26 percent) in areas not associated with human activities when compared with areas associated with human activities (44 percent). These differences were not significant. Generally, robins in urban areas appear to be more successful per nesting attempt than those on Comox Burn, Vancouver Island, British Columbia.

DISCUSSION

The importance of habitat structure is becoming increasingly evident (Parnell, 1969; Long, 1970). Some species have very specific habitat preferences, while others are found almost everywhere. Species found in a specific habitat type may have a food-oriented relationship, whereas species living in a wide variety of habitats may be selecting for some aspect of habitat structure (e.g., cover). Studies have shown that size and quality of food supply are correlated with breeding density and reproductive success (Lack, 1947; Miller et al., 1970). A characteristic habitat structure may also correlate with the above parameters.

The present study considered three hypotheses:

(1) Habitat structure can affect breeding density and distribution of pairs.

(2) Habitat structure is important to breeding success.

(3) Some components of habitat structure are more important than others.

Do robins have a common characteristic of habitat for which they tend to select? A survey through the literature reveals that their territories usually have open spaces. Horvath (1963) states that robins are concentrated in forests with a well stratified crown layer, poorly developed shrub and herb layer and general absence of bryophytes. Kilgore (1971) considers open habitat or edge as the preferred nesting place of the robin. Since this was not always directly related to food (Kilgore, 1971), edges or open spaces may be a basic habitat requirement of the robin.

A few studies have been conducted on gross features of habitat as related to biomass. Extensive logging operations in North America have provided opportunities to study effects of habitat alteration on avifaunal biomass. When an area has been logged, habitat structure is changed. Burning of litter and duff further amplifies this change. Sometimes different species populate such an area , and often there is a shift in frequency of occurrence of species present. This may, or may not, result in a change of biomass.

Michael and Thornburgh (1971) showed slash burning stimulated increases in total avifaunal biomass, but not hardwood removal alone. Emlen (1970) in the first five months after a removal of shrub strata, ground cover and dead litter, observed no change in number of species present or biomass. In his case, there may have been a shift in numbers of species the following year. His methods of censusing may, also, have obscured changes in biomass between the control and manipulated areas.

Kilgore (1971) found that robins rapidly responded to habitat changes that opened up an area. In giant sequoia (Sequoiadendron giganteum) forests in the Sierra Nevada Mountains, California, after cutting dead trees and slash burning, robin biomass almost doubled. Bock and Lynch (1970) found a sixfold increase in robin biomass in coniferous forests of the Sierra Nevada Mountains after a fire while total avifaunal biomass increased by little more than one-half. One problem common to the above studies is that

biomass is calculated from censusing small plots (8 ha) several times. If birds are not uniformly distributed throughout an area, results may be distorted by locally dense or sparse populations. However, the literature consistently reports that robins select for areas that have a high proportion of open spaces.

Evidence from the present study suggested a lower limit of "openness" which robins prefer. The dense habitat, consisting largely of plantation trees three to four metres high, supported a higher biomass than open areas. Open areas where almost all trees were less than one metre, had a low biomass of robins. There also seems to be an upper limit of overstory density in which robins thrive. In Douglas-fir plantation approximately 10 m high on Vancouver Island, J. F. Bendell (Pers. Comm.) observed a noticeable decrease in numbers of robins as density of coniferous cover increased. Robins seem to thrive best in habitat that represents an early seral stage of secondary succession.

Urban areas usually support a high population of robins. They typically have a density of five pairs per hectare, but have been reported at densities of twenty-five pairs per hectare (Howell, 1942). These estimates of density have frequently been computed for small areas, usually around a popular food source. Thus, they do not represent absolute density of an area.

Data published on other natural areas are probably more comparable to data from the present study. In natural areas,

Bock and Lynch (1970) found 4 pairs of robins per 40 ha on burned plots and 0.6 pairs on unburned plots of mixed conifers. Kilgore (1971) reported an increase from 21 pairs per 40 ha to 27 pairs (average for three years data), when understory of giant sequoia forests was opened by cutting and burning litter. Both of these studies were done on 8 to 10 ha plots in the Sierra Nevada Mountains. On Comox Burn, in 1971, dense habitat had 8 pairs per 40 ha while open areas had 6 pairs. In 1972, open areas remained at a similar density to 1971, while dense areas supported 11 pairs per 40 ha. These figures represent an absolute density and include tracts where no robins occur, as well as "robin rich" areas.

Nests and pairs tended to be distributed uniformly in dense areas with nests being more widely spaced than in open areas, although density of nests was higher in dense areas. Nests tended to occur in groups or clumps in open areas, especially in 1971. These clumps were usually distributed along streams. The reason for different distributions in the two habitats was not immediately apparent, but may be related to temperature or availability of suitable nest sites. In open areas, nests are frequently found at the bottom of a hill, near a stream, or half-way down a stream bank. These sites would have a higher relative humidity and would receive less direct sunlight for most of the day. This could be important during hot days, if females were incubating or brooding.

Few studies have considered details of habitat structure other than nest site characteristics, in relation to breeding success. Nests in dense habitat types were more successful than those occurring in open types. The respective distributions of nests in the two types may give some information on the differential success. Adequate spacing of nests, especially in dense areas, where vegetable food could be limiting, may be a distinct advantage. Clumping of pairs exhibited in open areas could depress nest success for several reasons: (1) competition for food, (2) greater frequency of intraspecific aggression, and (3) increased susceptibility to predation. Robins normally have a seasonal change in diet. They eat insects early in the season and switch to berries later. Dense areas have some fruiting shrubs, but fewer than open areas, generally. However, robins are opportunistic feeders and will feed on the most abundant food. It is not likely that their distribution is determined by food supply. Most cases of intraspecific aggression were observed when I stimulated a number of adult robins to congregate in a specific area while I was mist-netting and banding birds. Clumping may cause an increase in predation. If nests were close together, and one was discovered by a predator, the confusion might cause other females to flush, thus alerting the predator to their nest. In general, nests in clumps were not successful, except for one open area in 1971.

Considering general habitat structure, the present study

shows dense areas supporting a greater biomass of robins than open areas and nests built in dense habitat had a greater chance of success. Therefore, it is an advantage to nest in dense habitat, but, open areas are more frequently used after the young fledge.

Nest site characteristics have been described in the literature (Howell, 1942; Horvath, 1963; Kemper, 1971). Usually success was not found to correlate with particular parameters. For instance, Kemper (1971) found that robins preferred to build concealed nests, but could not demonstrate a relationship between amount of concealment and nesting success. She found that nest height, as well, was not significantly related to success.

A consideration of concealment, alone, was not found to be significantly different for successful or unsuccessful nests. I found no relationship between nest height and nest success. Although robins showed a preference to nesting near to water, it did not appear to have a distinct advantage for them, in terms of success. Type of site (tree, log, stump) was, likewise, unimportant to breeding success. Nests in sites surrounded by dense vegetation consistently showed a trend towards greater success than nests occurring in open vegetation. This difference did not prove to be significant. Hence, my findings suggest that of all nest site parameters considered, only concealment and density of vegetation surrounding the site bear any relationship to fate of the nest. Further analysis of the data revealed an

interrelationship between these two parameters and nest success.

As mentioned earlier, a nest in a site surrounded by dense vegetation was likely to be found in a dense habitat type, but could also be found in a clump of conifers in an open area. Concealment of a nest has relative amounts of importance, depending on the type of site used. A nest in open vegetation would be less "vulnerable", if it occurred in a well concealed site. Considering only nest site parameters in relation to nesting success, most successful nests occurred in dense vegetation, or in a well concealed site, or both. A smaller proportion of unsuccessful nests fit in the above category.

Nest success in relation to structure of habitat, according to results from this study, can thus be summarized:

A robin nest with one or more of the following characteristics, has a reasonably high probability of success.

(1) occurs in dense coniferous overstory
(2) is well concealed
(3) occurs in a site surrounded by dense vegetation

The role that general habitat structure and specific nest site characteristics can play in determining nesting success has already been discussed. It may also be important to consider the effect of individual robins on nesting success. There was evidence that individual females consistently built nests with similar characteristics and were consistently successful or unsuccessful. If most nest site characteristics are not a major factor in determining success of nests, then their consistency may not be important. However, they

tend to nest in the same type of habitat and this might be significant to the fate of their nests.

Another factor which may be important is individual variation of females in reaction to a disturbance. Some females would flush and call when I approached within 40 m from the nest. Others remained on the nest until I was within one metre. A tame female might have a good chance of successfully producing fledged young because she would not flush off the nest easily, thereby alerting potential predators passing through the area. Flushing tendencies may be related to general habitat structure or specific nest site characteristics. If a female flushed off her nest in dense habitat, it would be difficult to determine her place of origin. A female with a concealed nest in open habitat might clearly see oncoming danger and not flush until the predator was very near. In the above situation, a female flushing from a well concealed nest to open habitat would be very conspicuous.

Evidence supporting the fact that adults induce predation was provided at four deserted nests. I caused four females to desert their nests during early incubation and allowed the eggs to remain in the nests for the normal length of incubation period. All four nests were very exposed, two in dense and two in open habitat. None of these nests was disturbed. If this sample of nests was representative, the role of the individual in inducing predation may be significant.

Productivity in natural areas appears lower than in urban areas. Kemper (1971), in southwestern British Columbia, reported 87 percent success in nests where incubation was initiated. The present study had an average of 30 percent success. Snow (1958) reported a lower nesting success in wooded areas of Great Britain as opposed to an urban area for the European blackbird, a bird whose population dynamics and general biology are very close to the American robin. If population levels are stable in both types of areas, although at different levels, there must be a compensating mechanism. Several possibilities exist:

(a) Natural areas have a smaller nonbreeding surplus population. The literature frequently reports large nonbreeding surplus flocks of robins in urban areas. In the natural area studied, nonbreeding robins tended to occur in small groups, if at all.

(b) Natural areas have high rates of annual survival of adults. Although the sample size was small, rate of return was 22 percent higher for Comox Burn than that reported for robins in urban areas.

(c) Predators in natural populations may serve as less of a regulating factor than in urban areas. Predation on breeding robins was low on Comox Burn. "Urban robins" must cope with a high concentration of such "urban predators" as cats, dogs and children.

(d) There may be a difference in post fledging juvenile mortality in the two areas. In natural areas, juveniles must cope with a variety of avian and mammalian predators, but there is usually an abundance of cover. Juveniles in urban areas are extremely susceptible to "urban predators" during the first week after fledging, as a mowed lawn does not afford much cover.

Stable populations may result , at different densities, from differential mortality in natural and urban areas for adults and juveniles.

CONCLUDING DISCUSSION

Breeding density and nesting success of robins on Vancouver Island, British Columbia, were examined in relation to structure of habitat utilized. Two aspects of habitat structure were considered: general overstory cover and several nest site parameters. The hypotheses, as stated in the Introduction, raised questions as to the effect of habitat structure on density and nesting success of robins, and an evaluation of the most important components operating, of those examined.

Breeding density and reproductive success were found to differ in different amounts of overstory cover. In addition, a combination of concealment of the nest and general density of vegetation around the nest site was demonstrated to be more important to nest success than other nest site characteristics examined.

A number of trends were suggested by data which were insufficient to show conclusive patterns. At this point in time, these patterns remain questions.

(1) Does Comox Burn have a normal rate of return of approximately 70 percent of adult robins ?

(2) Does the population of robins on Comox Burn consist of successful and unsuccessful individuals ? This could have interesting implications in terms of population genetics.

(3) What is the role of the individual in inducing predation ? How does habitat type affect this behaviour ?

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APPENDIX I

There was a pronounced bias towards catching female robins in mist nets in both years (Table 2). The number of feeding trips made by male robins is equal to or greater than those of females, especially when nestlings are young (Kemper, 1971). Theoretically, there is an equal or greater chance of a male rather than a female being caught in a mist net. However, there may be a differential reaction to disturbance. In general, females scolded more viciously than males as I approached their nest. Males would scold for a short period, then perch silently in a nearby tree, or fly out of sight, even though they had food in their beaks. In some instances, the female was shy and retiring and the male was very aggressive. In few cases were both sexes equally aggressive.

While setting a mist net at a nest site, I would invariably be sighted by the adults as they made frequent feeding trips. After a nest was disturbed, the adults remained nearby and eventually went to check it. The most aggressive robin of the pair returned to the nest site first and was usually caught in the net. Since females were generally most aggressive, a bias towards catching females would be expected.

APPENDIX II

A large percentage (34 percent) of nesting attempts of robins on Comox Burn during 1971-1972 was unsuccessful due to predation. How does this predation occur? In a large number of cases it was difficult to assign a certain species or even family to the predation. Often there were clues as to whether the predator was mammalian (terrestrial) or avian.

Potential predators on the study area were marten (Martes americana), weasel (Mustela frenata), cross fox (Vulpes fulva), raccoon (Procyon lotor), red squirrel (Tamiasciurus hudsonicus), redsided garter snake (Thamnophis sirtalis), Puget Sound garter snake (T. ordinoides), kestrel (Falco sparvarius), Cooper's hawk (Accipter cooperi), red-tailed hawk (Buteo jamaicensis) and raven (Corvus corax).

Terrestrial predators were most important, constituting approximately 76 percent of total predations in both years. Mammalian predators , predominantly mustelids, were probably the most frequent predators.

The only observed predation was that of a garter snake (T. sirtalis) trying to ingest a 10 day old robin nestling in a nest on the ground.